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SYMPOSIUM

10–14 SEPTEMBER, 1990

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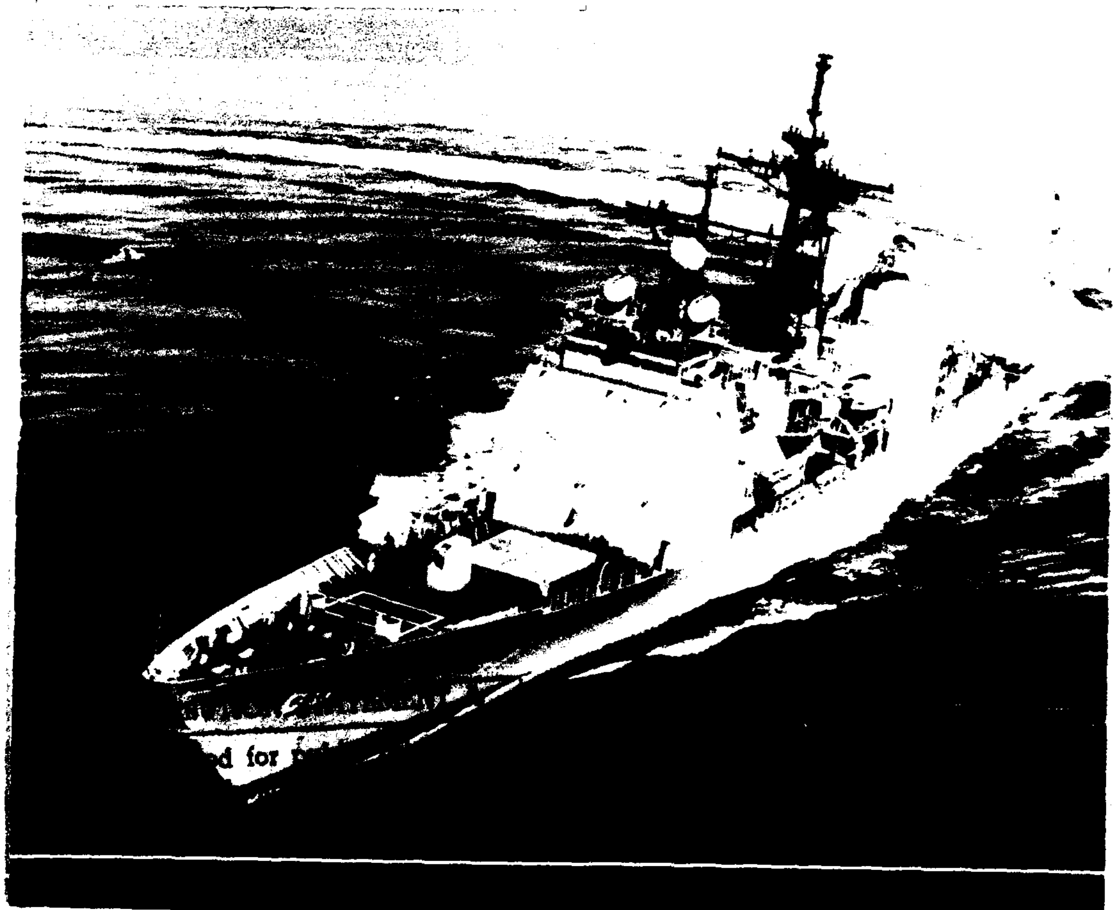
VOLUME 5

INCLUDING SUPPLEMENT AND INDEX



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FOREWORD

The accompanying four Volumes of these Proceedings contain the Technical Papers accepted for the first four days of the Ninth Ship Control Systems Symposium held at the Hyatt Regency Bethesda Hotel, Bethesda, Maryland, USA from 10 to 14 September 1990. This Volume contains the papers accepted for the 5th day, two alternate papers and the Supplement and Index. The Supplement provides background information about the Symposium and its participants.

The First Ship Control Systems Symposium was held in the USA in 1966, and subsequently in the USA(1969, 1978), UK(1972, 1984), The Netherlands(1975, 1987) and Canada(1981). In 1990 it is once again the turn of The United States to host the event, the Ninth Symposium in the series being sponsored by The Department of the Navy, Naval Sea Systems Command, USA. Organization of the Symposium has been undertaken by the Naval Sea Systems Command.

The Technical papers span the wide range of ship control topics: From Platform management, including damage control, manoeuvering, steering and stabilization control, to the monitoring and control of marine machinery. All of these aspects require the highest standards of engineering, science and mathematics to constantly improve on present methods and perfect new techniques. Indeed Technical Papers for the Ninth Symposium have been submitted from members of Government Organizations, Navies, Industry, and Universities, representing both Military and Merchant Naval interests of some 10 countries. Such a unique blend of participants and the fact that these tri-annual Symposia have now been taking place for 24 years, is evidence of the continuing value of the event.

Since the Eighth Symposium in The Hague, new developments are continuing to emerge in ship automation and control. The theme of the Ninth Ship Control Symposium is therefore "Automation in Surface Ship Control Systems - Today's Applications and Future Trends". The "Call for Papers" attracted over 120 potential Papers. The final number of Papers was eventually reduced to 96. A well balanced set of papers has emerged, reflecting both practical and technical topics. Some statistics concerning the breakdown of Papers can be found in the Supplement at the end of this volume.

The Proceedings of the Ninth Ship Control Systems Symposium provide a permanent record of the "state of the art" of ship control in 1990. It is hoped that these Proceedings, as have those of previous Symposia, will become a standard reference in the field of ship control. In addition, these Volumes will hopefully stimulate interest in ship control related topics from new parties, who will have the opportunity to participate along with the current contributors in the Tenth Symposium to be held in Canada in 1993.

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TRAINING FOR MACHINERY WATCHKEEPERS

by

B. Taylor, CAE Electronics Ltd.
LT(N) K. Isnor, Canadian Navy

1. ABSTRACT

The training of machinery watchkeepers has emanated from a traditional hands-on approach that started at the turn of the century. This approach was valid in acquiring knowledge essential to the local operation of machinery. As the automated machinery control room came into being, so did the land based machinery control console simulators. These simulators provided the machinery operator with the ability to train on a control console without the added risk of damage to the shipboard machinery.

Using complex software models and the processing power of modern computers, these land based simulators are capable of presenting realistic scenarios to the operators.

The high cost of the simulator has been a limiting factor with traditional machinery control systems. The introduction of the "glass control room" in the Canadian Patrol Frigate, the DDH 280 Destroyer, and the MHC-51 minehunter, has resulted because of advances in machinery control systems. This has also opened the way to integrating high performance general purpose computers with these latest technology control systems to produce high quality land based trainers.

A natural follow-on to the modern land based trainer is the onboard embedded trainer. The latest technology control system architectures utilize multiple control consoles to increase system availability. One of these multi-functional consoles can be taken off-line to interact with a computer simulation and provide in-situ training without affecting the operation of the control system, and thus the ship. This embedded trainer can also have the same simulation capability as the land based trainers.

2. INTRODUCTION

The role of the navy in peacetime is to train for war. In the context of the total ship there are varying degrees of priority assigned to training of different departments. Some departments have roles that are support in nature, whereas others have front line operational roles, and therefore have priority when it comes to training.

In the past, marine engineering training has been limited by operational requirements, not the least of which has been to keep the ship afloat and moving. In the overall context, the marine engineering department is definitely considered as a support department. Any training activity that could possibly damage the machinery was not permitted as a damaged ship could reduce the operational effectiveness of the mission and the ability to train the remainder of the crew. To quote a ship's Captain;

"It is difficult to keep station when you are dead in the water."

However in order to permit the marine engineering department to fulfill its training requirement, the concept of engineering emergency drills training was introduced into the Canadian Navy. This training initially took many forms, from descriptive problems passed on pink slips of paper to the operators, through to the actual tripping of critical machinery. Notwithstanding the degree of realism one gets from actually stopping and starting machinery, there is still a danger that damage can occur to the machinery. A side benefit of this is the experience the department gets in repairing it's mistakes; also an essential part of training for war.

The introduction of the central control room concept brought with it the land based trainer. In the early days of land based trainers, the operational training was limited to simulating procedural aspects, primarily because the simulation capability of the trainer was limited. As the land based trainers evolved, so did the sophistication of the simulation supporting these devices. Today, it is possible to simulate any operational activity on the land based trainer. The current problem is to get sufficient time on the trainer for each member of the crew.

As control systems have evolved to the present modern architectures, so has the ability of introducing a trainer into the ship. Modern computer assisted learning facilities currently available, can provide all of the procedural training

requirements for on-board training. However, they fall short in taxing the abilities of the watchkeeper to his limits under periods of duress for the ship where the operator may be faced with a number of disasters with the plant. Thus this is the true role for an on-board embedded trainer.

3. BASIC WATCHKEEPING TRAINING

In the navy of the 1970's, engineering training was part of the on-the-job training process. The trainee would first complete the engineering theory courses at the Fleet School and then a limited amount of practical training in either the harbor training ship or on the training simulator. At this point in time the operator would have completed the basic procedural training, but still required a great deal of experience in order to consolidate this knowledge. This experience came in the form of his day-to-day job where the individual learned through his and others mistakes. The trainee was guided by experienced Chiefs and Petty Officers with years of steaming experience.

During the period of the 1970's many of these "old and bold" Chiefs and Petty Officers retired from the Navy. The vacuum they left behind was filled by less experienced individuals, and thus the existing training methods were being eroded. The training structure had to be modified to cater to the less experienced Chiefs and Petty Officers taking their place. If these new Chiefs and Petty Officers were not comfortable with the engineering drills, then the quality of the training passed onto the operators was in question.

4. ENGINEERING DRILLS

During the 1970's, engineering drills were conducted on a day-to-day basis through a paper process. In general, this process involved a colored piece of paper describing the emergency situation. Upon receipt of the paper, the watchkeeper was expected to tell the Chief what steps he would take to handle the particular situation. This was an oral process and did not involve the actual stopping and starting of machinery. Thus the watchkeeper never really felt the pressure of the emergency situation.

During the normal operating cycle of the ship, there were periods when the Sea Training Organization would come onboard to assess the capability of the Captain and his ship's company. A part of this Sea Training Organization was the engineering staff. When the engineering staff set to work on the emergency

drills and procedures testing, it was not done with a piece of colored paper. The emergency drills were conducted in an organized manner and the actual machinery was tripped and taken off-line to see how the watchkeepers would act in the heat of the moment. Needless to say, this form of drills is much more difficult than the paper process. The watchkeepers did not look forward to the visits of the Sea Training Staff, primarily because they were not prepared for the process.

In the mid-1970's, it was recognized in the Canadian Navy Training Squadron that it may be possible to move away from the paper drill process to a more realistic set of drills, more closely patterned after those conducted by the Sea Training Organization. This was done by scheduling all of the drills in conjunction with the normal operational schedule of the ship so as not to interfere with the Speed Of Advance (SOA) of the ship.

After a great deal of planning and practice, the implementation strategy became one of conducting the drill to develop the watchkeeper's skills through repetition. The drills were conducted as follows:

a. before proceeding on watch, the watchkeepers would be told what drill to expect and when to expect it;

b. a few minutes before the appointed time, the Chief Engine Room Artificer (CERA) would confer with the Chief of the Watch to ensure that he was comfortable with the situation;

c. the appropriate safety numbers would be put in place along with essential items such as stop watches;

d. at the appointed time for the drill, the CERA would cause the applicable machinery to fail; and

e. the watchkeepers would respond to the drill.

Initially, there were mistakes made and they manifested themselves in the form of broken pumps, burned out bearings, and SOA delays. After several months of practice, the watchkeepers found that they could handle concurrent drills without any difficulty. It was also discovered that some of the procedures were not ideal, and after experimentation, they were modified. Notwithstanding the desire to move to unannounced drills, the above process was not modified; drills

were not sprung on an unaware watchkeeper and thus confidence was developed in the people and the process.

The proof of success came when the Sea Training Organization revisited the training squadron ships for "WORK-UPS". The philosophy taken by the engineering watchkeepers was that this was just another drill. WORK-UPS were a success. In fact the Sea Training Organization was so impressed with the Training Squadron methods, that they became the Fleet standard for all of the steam powered vessels in the Navy.

The follow-on to this process was to develop a similar set of procedures for the gas turbine powered ships that were operated from a central control room. In this case the implementation was a little more difficult because the line of communication between the Chief of the Watch in the control room and the stoker in the engine room was not as direct. Notwithstanding this problem, a similar process was implemented and continues to be successful today.

In the DDH 280 class of destroyers, it was found that the machinery control console trainer was very useful for training the watchkeepers on the procedures required for engineering drills. Although the simulator was extremely limited in capability, it was useful for the initial stages of training new personnel. If the trainer had more simulation capability, and if it had been more than a one shaft line trainer, it may have served the Navy better for refresher training. However, having made these points, one should remember that the trainer used analogue technology, having been built in the early 1970's.

Presently for this engineering drill process, most of the operational programs now allocate several hours per week to the Engineering Officer to conduct emergency drills procedures. The method is not 100% "stoker proof", and therefore every now and then one of these drills will manifest itself in the form of a damaged pump or engine. This is the price of conducting the primary peacetime role of "training for war". When damage does occur, there is the additional training benefit of conducting maintenance and repair work under conditions at sea. This provides the ship's staff with much needed maintenance experience.

5. NEW GENERATION TRAINERS

In the last few years a new generation of machinery control system trainers has been developed by many vendors. These

trainers have demonstrated an enhanced simulation capability through the introduction of modern high performance digital computers. The high performance digital computer has permitted detailed modelling so that the machinery plant is no longer modelled as a set of simple on/off or linear models. Non-linear models of pumps, motors, compressors, engines, electrical switchboards, and other equipment have truly enhanced the capability of the marine control system simulators. The operator is now permitted to attempt any possible sequence of events that the machinery will allow. He is no longer limited by the capability of the computer or the analogue stimulator of the older trainers.

In conjunction with the capability to simulate machinery models, these new digital computers provide the designer with the opportunity to install an instructor facility that is very flexible in its operation. Through the use of structured software programs, the instructor can load pre-defined lesson plans and execute them in either an automatic or manual mode. The instructor can change the lesson plans "on the fly" for the student who is showing high levels of skill, and he can "daisy chain" many lesson together. All of these events can be digitally recorded on an event logger, and thus available for future playback. The digital computer has truly brought the realism of flight simulators into the marine control system trainer environment.

This type of trainer can be used as a part task trainer for each member of the watch, or it can be used as a team trainer to provide cohesive training for the entire watch simultaneously. Team training not only includes training on the main control room consoles, but also training on the engine room local operating panels. In addition to watchkeeping procedures and drills, the trainer can also provide for training on the Equipment Health Monitoring (EHM) software thereby permitting operators to diagnose faults in the machinery. Additionally, these trainers can provide the capability to diagnose control system failures through the Built-In-Test-Equipment (BITE).

Notwithstanding all of the benefits of the modern trainer, it should be remembered that this type of training approach is expensive. The trainer must be housed in a building, an instructor must be on site to run the system, there are maintenance requirements, and the entire facility has the normal overhead costs. In other words, training in this form is not inexpensive over the life cycle of the equipment.

Whether the Navy will show a higher personnel turn over rate than in the past due to the current demographic trends and a demand for skilled technicians that is occurring in Canada at this time remains to be seen. This could mean that the shear volume of training will increase, and hence the usage of trainers. Given the limitations of training time, a single land based trainer will find itself as the bottle neck of the training pipeline.

6. CONTROL SYSTEM DEVELOPMENTS

In the last decade marine control systems have evolved from the traditional point-to-point architecture of the DDH 280 class ships. This architecture, shown in Figure 1, along with its numerous "conventional type" instruments, was the mainstay of the early warships that used central control rooms. The Man-Machine Interface (MMI) was neither user friendly or ergonomically designed, and yet was made functional through increased levels of training. In this traditional control system architecture, the control consoles are generally broken out by function, i.e. a propulsion control console, a damage control console, and an electrical control system console.

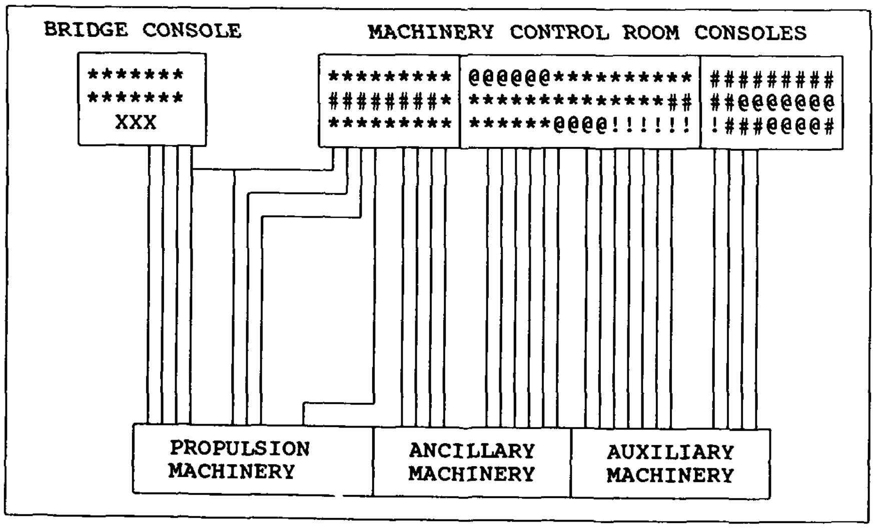

Figure 1. Traditional Control System Architecture

In some Navies, the traditional architecture has been replaced with a "combinational" architecture. This architecture, shown in Figure 2, provides for point-to-point wiring for control signals and uses a data bus for gathering and distributing all monitored signals. The MMI has a combination of conventional instruments and a visual display unit for the monitored information. This MMI design is much more user friendly than the traditional console as it is ergonomically designed. The improved design of the MMI has resulted in reduced training time.

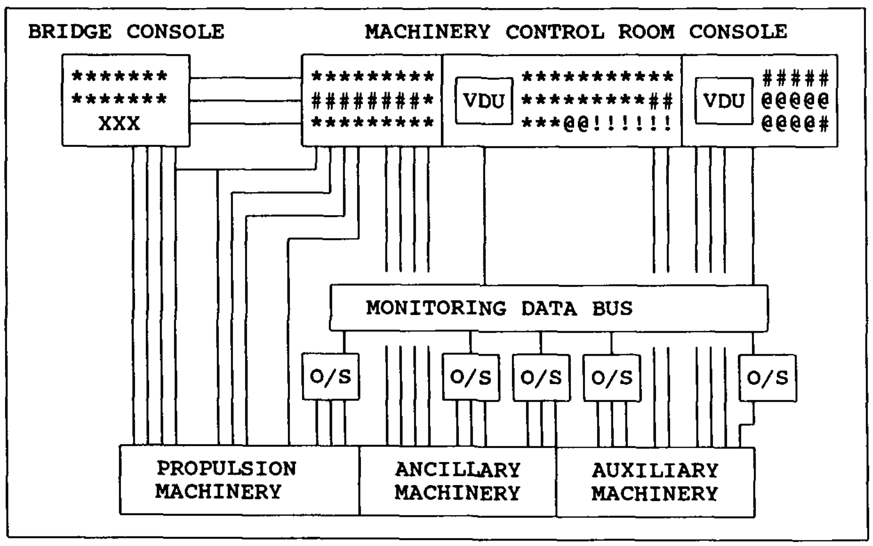

Figure 2. Combinational Control System Architecture

In Canada, the DDH 280 modernization program and the Canadian Patrol Frigate have seen the introduction of a new generation of distributed control system. This system utilizes a triplicated data bus to pass all signals from the plant to the control room, as shown in Figure 3. This generation of control systems does not utilize any conventional instruments at the control room consoles. All control and monitoring data is displayed to the operator on a color visual display unit. The MMI on this system is ergonomically designed and easy to use.

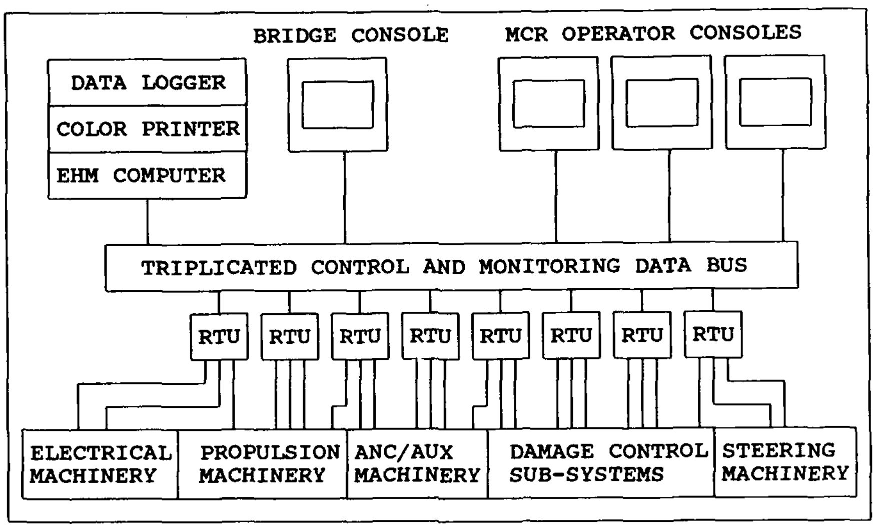

Figure 3. Data Bus Control System Architecture

7. ONBOARD TRAINERS

One of the methods of reducing the overall life cycle cost of watchkeeper training is to introduce the concept of the onboard trainer into the machinery control system. This concept would see a ship's control console used as a trainer during periods of low operational activity, for example during the middle watch on a long transit.

If this concept is successfully implemented, then the land based trainer may not be required for refresher training and can be dedicated to initial training and team training only. By training the watchkeeper in his own environment at sea there will be no reluctance to make training a high priority item. In the case of the onboard embedded trainer, training can become a part of the normal ship's routine, and thus not continually deferred.

The traditional control system architecture does not readily permit the use of an onboard trainer since:

a. there is only one console in the control room, and it is required at all times to interface with the machinery plant; and

b. if this console could be used as a training device, the local operating panel becomes the station-in-control, then the number of duplicated connections between the console and the trainer simulation computer may make installation impractical.

The "combinational" control system architecture has a potential to be used for training purposes. The limitations would be the signals that are wired in a point-to-point configuration, and the requirement for a redundant console. The Visual Display Unit (VDU) portion of the combinational control system architecture system could be used for onboard training if the control room contains more than one console.

The data bus control system architecture with its VDU based MMIs lends itself ideally to the integration of an onboard trainer by:

a. all control and monitoring signals travel on the data bus, therefore the signals, which are available to all MMIs can be replaced at one console with a set of training computer inputs and outputs relatively easily;

b. all MMI inputs and outputs are presented through software on a VDU, therefore there are no conventional instruments that need to be connected to the simulation computer and to the plant; and

c. by design, there is more than one control room console. It is therefore possible to remove one of these consoles from the data bus, in software only, and use this unit to provide operator training. The simulation would be provided from a digital computer.

The concept of an onboard trainer is depicted in Figure 4. This concept provides the ship with the capability to take a control and monitoring console off-line while at sea, and execute operator training. The ship and its machinery would be controlled from one of the other consoles. In the event that a "real world" alarm is detected by the control and monitoring system, the console under training could be reverted back to its main function within 15 seconds.

In the data bus control system architecture there are a number of control consoles. Each of these consoles has the

capability to control and monitor any of the machinery plant functions listed below:

a. Propulsion machinery;
b. Ancillary machinery;
c. Auxiliary machinery;
d. Electrical generation machinery;
e. Electrical distribution systems;
f. Steering machinery and autopilot;
g. Damage control subsystems; and
h. Equipment Health Monitoring.

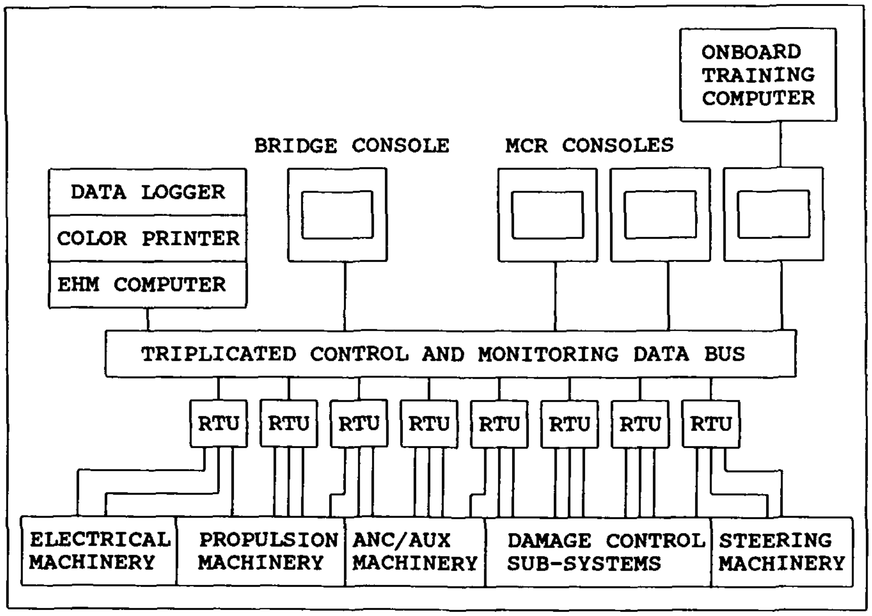

Figure 4. Data Bus Control System with Onboard Trainer

In the event that one of the consoles was in training mode and a real plant situation did occur, the Chief of the Watch would make the decision as to whether he or another operator could handle the problem, or the console should be removed from training to deal with the situation. If one of the consoles was under training and all of the other consoles on the data

bus became unserviceable, then system would detect this and automatically revert the "training console" back to real time control of the machinery.

The introduction of the onboard trainer to the consoles in the machinery control room could be achieved through an additional circuit card in the console. This additional circuit card will provide an interface to the console from the simulation computer. The software contained in this circuit card will provide the ability to switch the console from the "real world" to training and back, without the requirement for the operator to reconfigure any hardware.

To maximize the capability of the onboard trainer, the training software already developed for the land based machinery control system trainer can be used. In this manner, the instructor software and the operating system will be common for both trainers. Therefore, the onboard trainer will be able to capitalize on the courseware already available for the land based trainer.

The concept of onboard embedded trainers is being pursued at CAE at this time. It can provide the Navy with a much improved capability of training machinery watchkeepers. This concept may have initial teething problems, but on the whole, it should provide the capability to enhance the degree and quality of training given to the marine engineering department.

8. CONCLUSIONS

The number of personnel requiring watchkeeper training has increased over the requirements of the 1960's and 1970's. Therefore, the cost of training has increased with time. In times of peace, the operational role is to train for war. To do this in a cost effective manner, new technologies have been introduced in the form of control system architectures and computers for shipboard control. To be effective, the Navy should use these new elements of technology to operate and train in the operational environment, at sea.

The data bus control system architecture with its color visual display unit man-machine interface lends itself easily to the integration of an onboard trainer. The onboard trainer will provide the Navy with the capability to use one of the machinery control room consoles as a trainer while the shipboard machinery is being controlled from one of the redundant consoles. This application of new technology will see training being conducted on a more frequent basis, and will see a better utilization of those long middle watch hours. The end result will be a better trained watchkeeper.

9. REFERENCES

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10. DISCLAIMER

The opinions expressed in this paper are those of the authors and, as such, are not necessarily endorsed by the Department of National Defence (Canada).

VESSEL RESOURCES MANAGEMENT
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ABSTRACT

The professional mariner works in an increasingly complex environment composed of dynamic and interrelated technical and social systems. Vessel Safety *has long been the mariners'* primary responsibility and until recently was assumed to be the logical result of finely tuned technical skills known as seamanship. But seamanship alone does not give the mariner the knowledge and skills necessary to manage the interrelated technical and social systems.

Vessel Resources Management is the effective utilization of hardware, software, and liveware to achieve safe and efficient vessel operation. Following carefully crafted, real-time scenarios, vessel officers learn to simultaneously manage both systems. The full-mission bridge and engineroom simulators of the Maritime Training and Research Center (Toledo, Ohio) are coupled in such a way that deck and engineroom officers must coordinate their efforts, communicate their decisions, mutually "trap" errors, and monitor their crew's efforts to achieve a safe "voyage".

Variations of Vessel Resources Management have now been developed for, and presented to, mariners of the United States Coast Guard, the U.S. inland waters, and the Great Lakes. Preliminary results indicate that this application of simulator technology will have a significant impact in the safety of vessel operations (including accident reduction) and in the efficiency of vessel operation (including fuel consumption and maintenance costs).

The professional mariner works in an increasingly complex environment composed of dynamic and interrelated technical and social systems. Vessel safety has long been the mariner's primary responsibility and until recently was assumed to be the logical result of finely tuned technical skills known as seamanship. But seamanship alone does not give the mariner the knowledge and skills necessary to manage the interrelated technical and social systems.

Come aboard a complex modern vessel as she enters a busy port. From the ship's bridge we can see the "environment". There are bridges, piers, docks, other vessels in motion and vessels at anchor. There are small boats, large boats, ferry boats and sail boats. There is wind and tide and current and daylight or dusk or dark.

The vessel itself is a complex technical system. There are engines and rudders and thrusters for movement and control. There are charts and receivers and loran for navigation. There are short range and long range radios for communication. There are gyros and repeaters and signaling devices for stability. And there is radar to see what is and to predict what will be.

On the bridge is a part of the ship's social system. There is a captain and a watch officer, a pilot and a helmsman. Each is a polished expert at his job. The captain knows his vessel and her characteristics. The watch officer is backup to the captain and keeps careful note of his vessel's position in relation to the environment. The pilot knows the local waters, this harbor, its uniqueness and its dangers. The helmsman responds to commands quickly and accurately.

There are other parts to the social system: the engine room officers and crew, the galley officers and crew, the deck hands, and others. Each is highly skilled, each is separate, each is interrelated to the whole.

The radar screen is a point where the technical and the social systems interact. Marine radar shows not only the shoreline and other vessels. It plots the right now and predicts, for six minutes hence, the location of other vessels, large and small, underway or still. It is truly a magic black box to show the social system what "will be". It is an invaluable tool in close quarters maneuvering. It requires formal coursework, much practice, and careful thought to master the modern ARPA display.

The radar is a frequent stop as the captain and the pilot bring our vessel into harbor. The radar keeps the social and technical systems placed within the environment. It helps maintain the separation needed for safe maneuvering.

In a now famous case, the radar screen went blank. No longer was there a picture and a prediction. The watch officer, the pilot, and the captain all gathered around the now dark screen. They discussed possible causes, they fiddled with the controls, they focused all their attention on a breakdown of the technical system. The helmsman continued to maintain his course and the engineroom crew continued to maintain the last called for speed.

This vessel and its crew with finely tuned seamanship skills ran into another vessel. There were injuries but no loss of life. There was damage but neither ship sank. The cargoes were saved but both ships required extensive repairs.

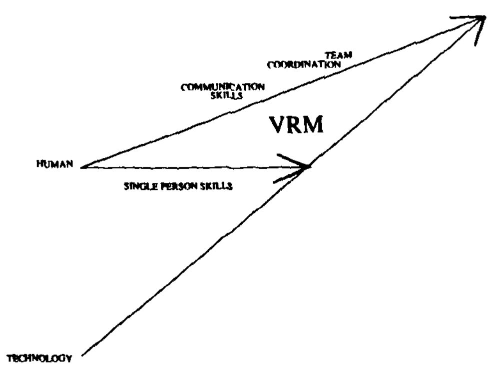
Mr. C. P. Srivastava, the Secretary-General of the International Maritime Organization (of the United Nations) said in his annual address on World Maritime Day: "It would, of course, not be realistic to expect that maritime accidents can ever be completely eliminated. The fury of the elements knows no bounds and some casualties will occur. Unfortunately, some of these accidents cause the loss of precious human lives, apart from the loss of ships themselves and their cargoes. We have, in the past year or so, been deeply shocked and greatly saddened by several tragic maritime casualties which have occurred in many parts of the world.

"As enquires into maritime casualties show, most maritime accidents are caused by *human error.* (The IMO has) agreed that something more can, and should be done ... it has been agreed that special attention should be focused on *shipboard management-* ... (emphases added) (IMO News, 3:88)

Vessel Systems

The explosive growth of technology has not bypassed the maritime industry: electronic vessel controls, loran with its pinpoint navigational accuracy, and the ARPA radar are quick illustrations. New communication tools allow ship owners to speak with captains anywhere in the world. Loading and unloading is now done in hours where not many years ago it took days and sometimes weeks for vessel "turnaround". And ships are big and bigger as materials and hydrodynamics work together in new ways.

But the social system is much unchanged. The captain is by maritime law and tradition, the master. Watch officers, engineroom officers, galley officers, and the entire crew follow his lead and respond to his direction. And each, as an individual, is assumed to have those highly polished single person skills.



When the technical systems were simpler, the strength of a vessel was its social system and each person's seamanship skills. The human skills could successfully manage the technology.

But as Figure 1 indicates, the technologies have grown to the point where individual skills are no longer adequate. The single person skills need to be augmented with team coordination and communication skills. And these new skills must be practiced and honed and developed with the same care as the old seamanship skills.

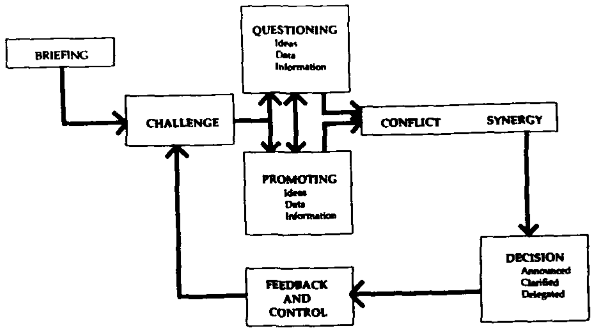
Vessel Resources Management is the means by which these new skills can be taught. VRM is both a learning program and a perspective for todays professional mariner.

Vessel Resources Management is part of the response Mr. Srivastava describes. The purposes of VRM are to improve vessel safety and to increase the efficiency of vessel operations. The methodology is to develop new shipboard management skills on the part of the captain, the chief engineer, and the entire crew. Vessel resources management is the process that matures the social system skills so those skills can again manage the continuing advances in the technical system; to reduce the gap that imperils vessels and their crews.

Many times the maritime social system does not accept a statement such as; "Captain, this does not look right." As we sailed into harbor, surely the helmsman saw the other vessel. But the captain, the watch officer, and the pilot were otherwise engaged so nothing was said. The technical need for ARPA radar and its failure to function, caused shipboard management to miss the human error.

Had the captain and crew been trained in vessel resources management they would have acted much differently. Recognizing the ARPA radar failure as a challenge, the captain would have followed the paradigm shown in Figure 2. The captain would have framed the challenge, raised questions concerning it, solicited ideas and suggestions, and finally articulated his decision and the attendant responsibilities of each person. He would have established processes and set up control mechanisms to permit safe maneuvering without the ARPA. And had one cycle failed to trap the error of "everyone watching the broken radar", the VRM trained helmsman would have framed the challenge of the impending collision without fear of retribution.

Vessel Resources Management



The vessel resources management skills are triggered by a challenge to the status quo, the challenge may come from outside: weather, other vessels, the shipowner - or from the vessel itself: equipment failure, accident, or human performance failure. The challenge may be stated by any member of the crew. Questioning and promoting are currently under- used shipboard management skills. VRM supplants the old "individual knowledge" with team communication and information generating which results in more knowledgeable and correct decisions made by the captain.

Many times a vessel is put in jeopardy when a subordinate is afraid to frame a challenge or promote an alternative to a senior officer. The helmsman may "know" that the captain does not tolerate being interrupted or being "told how to operate" his vessel.

Conflict

Ideas, data, and information generated this way may develop conflict. There may be more than one acceptable alternative. The sources of information may not agree. The pilot may feel that radar is not required for safe passage, the watch officer may feel that immediately coming to anchor is the safest practice. Conflict leads to the potential for synergy - a better solution than any single person could have produced.

The decision belongs to the captain; the responsibility continues to be his. But VRM adds to his decision responsibility a requirement to announce the decision to all concerned. VRM trained crews do not accept decisions which are not clearly stated so that each person is fully aware of the "captain's intent". VRM trained crews expect to be free to seek clarification if they do not understand intent or their assigned tasks.

Finally, VRM demands that a feedback and control structure be established to assure that the challenge is resolved. Simple, standardized structures work

best but creative and unique structures are sometimes required. A failure in the monitoring process becomes a new challenge to the vessel crew.

Resources management is a conscious process. It requires reaching out and tapping into all the available resources; hardware, software, and liveware. It requires the recognition that the maritime technical system is too complex for a single person to know it all. It requires that each crew member learn to suggest alternatives, to identify potential errors, and to reach to other resources. It opens the door in the social system for a subordinate to offer an idea, a suggestion, or a warning.

The Vessel Resources Management syllabus includes these team coordination and communication skills: situation analysis, communication, problem solving, decision making, delegation, motivation, error trapping, team development, stress management, leadership, followership, conflict, synergy, and performance observation and critique. The training course is five days and four evenings of intensive learning and hands-on practice in the simulator.

Maritime Simulation

Maritime simulators have been used extensively for developing these finely honed individual skills. The speed, safety, and stop-action capabilities of the simulators encourage repetitive drills of critical seamanship skills. Docking, undocking, tuning, changing speeds, sailing a course, and identifying lights are all necessary skills that capitalize on the capabilities of a simulator.

This use of a simulator is akin to baseball's batting practice. It keeps one's hands and eyes and mind sharp. It can develop and maintain a high level of individual skill. But batting practice is not the same thing as playing a real game.

Vessel Resources Management requires a different kind of simulation. Captains, and chief engineers, and officers learn the VRM skills when they experience the actual shipboard management of the technical and social systems. These new coordination and communication practices begin to make sense when there is visible success based upon the use of these practices on a "voyage". VRM skills need to be practiced in a more "real life" setting than the stop-action of simulated docking. And these skills can be learned through both personal practice and through observing the practices of others; batting practice is only of marginal help to the observer.

Learning and practicing new skills requires a full complement of personnel in both the engineroom and the bridge. People need to become helmsmen, and oilers, and watch officers, and captains by performing the duties of those positions. They need to frame challenges, promote ideas, help develop alternative responses, and then carry out the captain's decision. VRM demands new social system skills and a session of batting practice does not meet that need.

The key to VRM success has been the capability at the Maritime Training and Research Center (MTRC) simulator to couple the bridge and the engineroom in real time. What happens in the engineroom is reflected on the bridge. The challenges facing the bridge also impact the engineroom. The speed and accuracy with which the framed challenge is communicated to engine room or bridge becomes a clear measure of VRM learning.

VISUAL SCENE

- Full Color
- 182° Horizontal Field of View Forward
- 26° Horizontal Field of View Aft
- 26° Vertical Field of View
- 3.1 Arc Minutes Pixel Resolution
- Rear Projection
- Matches Radar Display Within 0.2 ft.
- Objects Approached to 0 ft.
- 30 Hertz Screen Refresh Rate
- Very High System Reliability
- Excellent Brightness
- Excellent Linearity
- Allows Accurate Visual Bearing Taking
- Object Occulting
- Good Range Light Sensitivity
- Accurate Aids to Navigation with IALA Flash Patterns
- Over 400 Lights at Night with Silhouettes

Remote Monitoring Console

The bridge and its equipment are detailed in Figures 3 and 4. The equipment is typical of a modern vessel in both content and layout. The physical size of the bridge is large enough to permit a full complement of personnel plus observers. The Remote Monitoring Console (Figure 5) provides enough space for additional observers and staff to monitor the progress of the "voyage".

The engineroom display (Figure 6) and control room (Figure 7) also conform to the typical modern vessel in content and layout. Again, there is sufficient size to include a full complement of chief engineer, watch officer, oiler, and observers. The control room offers additional space for observers of the "voyage".

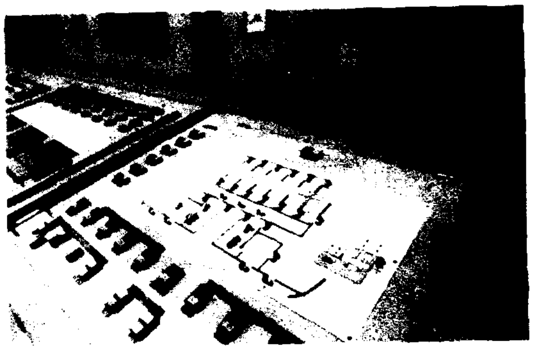


Figure 6

Figure 7

Bridge requirements for speed and direction are repeated to the engineroom for execution. Basic engineroom activities such as engine RPM are repeated to the bridge. Sound phone and regular phone communications are available. Conversations on the bridge and in the engineroom are broadcast to both the control stations. And the control stations are in continuous voice contact.

Participants in the VRM programs "sail" carefully crafted scenarios. Each scenario is written so that one or more of the VRM skills is emphasized during the voyage. Each scenario includes both simple and complex challenges. Simple challenges are those which can be resolved with the resources available; complex challenges require that the vessel crew work around that challenge for the rest of the voyage.

The specific challenge and the timing of the challenge are written into the script. However, the instructional staff has the option of not introducing a challenge, or changing the timing of the challenge, based on the performance of the learning team. Challenges are designed to be resolved; there are no impossible missions. The fundamental learning philosophy is success, not failure.

Elements of VRM

There are three elements to VRM learning. First is the classroom which is used to describe and define the VRM skills. The classroom process includes lectures, discussions, exercises, and role plays. The simulator phase focuses on solving real problems in real time. Normal, abnormal, and emergency conditions are included as part of the challenge scripting. Focused observation *is a critical* part of the simulation phase as there are learner observers in the engineroom, on the bridge, and at both control stations. The final phase is feedback. Team and individual self-critique focus on the skills employed "well" and the application potential in "real life". Peer critique from the observers is focused on the entire VRM paradigm - that is, the use of all the VRM skills during the voyage.

The typical VRM course is made up of an equal number of captains and chief engineers or deck and engineering watch officers. The experience level is usually high with over twenty years' service the norm but with some participants having had fewer than ten years' service.

Each scenario is conducted as in actual practice. A vessel team will consist of a captain, a chief engineer, a deck watch officer or two, a helmsman, an engine watch officer or two, and an oiler. There will be assigned observers on the bridge, in the engineroom, and at the control stations. "Playing the position" can be difficult since the vessel captain and helmsman are both "real captains". But, usually after the first few minutes of the voyage each participant plays his position to the learning advantage of all.

Each voyage starts with a captain's briefing. Captains are expected to inform everyone, including at least one member of the engineroom team, of at least the following information:

* position and type of vessel
* nature of voyage (to and from where)
* planned navigational route
* weather, tide, and current
* speed
* personal preferences (repeated orders, etc.)

The Chief Engineer is also expected to brief the captain on this minimum list:

* limitations of engine machinery
* maximum speeds and turn rates available
* on-going maintenance during the voyage
* availability of anchoring equipment

Each 'voyage' is planned to take about fifty minutes. The initial briefings usually take about ten minutes and personal preparation such as watch officer chart familiarization also takes about ten minutes. An early concern was that these voyages would be too short for learning and practicing the VRM skills. Experience has shown that these fifty minutes are intensive learning periods. Longer periods tend to either be repetitive or to cause the teams to revert to their former communication and coordination patterns.

Debriefing and Feedback

After each voyage, the observers hold a debrief of the team's performance. The focus of the debrief is on the use of the VRM model and the results of the VRM practices. Recrimination, finger-pointing, and put-downs are not encouraged; sometimes the staff has to st[illegible]p in and control the debrief. Critiquing captains and chiefs is not a typical m[illegible]me practi[illegible] but has been well accepted in these courses. Self-critique has [illegible]n bett[illegible]ceived than we had anticipated.

All voyages are videot[illegible] br[illegible]ge control station. All bridge activity and conversation, communicatio[illegible]th the engineroom, and all non-vessel radio links are included on the tape. These tapes are used during the debrief/feedback session and are then presented to the captain for his disposal.

Error trapping, capturing the chain of human error, before an incident or an accident is a primary emphasis of VRM. We use both canned and live exercises to teach error trapping.

In the classroom we use video tape re-creations of maritime accidents to practice. These re-creations clearly demonstrate the lack of team coordination, the use of ill-conceived problem solving models, and a generalized "individual skill" approach to resolution. After exposure to the VRM concepts, errors seem to pop off the screen. Groups sometimes even talk to the actors - yelling out, "No, not that way!"

It is on the voyages that error trapping becomes a new skill. The VRM paradigm encourages the helmsman to wrench the captain from the blank ARPA radar and demands that he maneuver away from the approaching vessel. The chief engineer no longer agrees that all is "ok" when in fact all steering control has been lost. The third mate speaks up when hitting a bridge piling is still a far-off probability. And the captain still makes the decisions, is still the master.

Preliminary Results

Preliminary results of vessel resources management have been encouraging. Captains, chief engineers, and company managers have told us that there is a new level of communication aboard vessels with some VRM training. The deck and engine departments have initiated coordination. One vessel team found a way to maintain a critical machine and still provide all the "up and available" time needed. Conversations between officers now include concerns of communication and coordination in addition to "sailor talk".

Some captains are beginning to see their function in a much broader perspective. No longer locked in on the all-knowing master role, they are discovering the thrill of delegation. As subordinates assume more complex responsibilities, the captains discover they can be shipboard managers.

We have forecast fuel savings of $60,000 or more for one VRM trained fleet. This savings will come from better coordination between captain and chief as they plan vessel speeds and voyage timing. The same fleet expects reductions in its repair and maintenance costs for all VRM trained crews.

The full-mission coupled simulators are the critical capability in the introduction of VRM skills to the maritime industry. Neither classroom nor real life can duplicate controlled experiences in team coordination and communications. In real life, each mariner reverts to his finely tuned individual skills to resolve challenges unless and until he has learned and mastered the VRM process and practices.

It's always easy to say:"This is what he/they should have done----." But what we want is *not* to have to go back and say this is what they should have done for they will have already done it.

The simulator creates a significant cultural change with new communication and coordination patterns which changes the social system and thus also changes the social-technical dynamics and interface. No longer does one person have to remember all the information and every piece of operating data. No longer does one person have to rely on his own knowledge, skills, and experience.

We are developing new sets of seamanship skills to join those finely tuned individual skills: we are adding team coordination and team communication.

Initial classes in Vessel Resources Management are meeting our expectations. Major great lakes, deep sea and US government fleets have committed to VRM as an operating procedure and as a means to improved vessel safety and operating efficiencies. Training is now being conducted regularly at the Maritime Training and Research Center in Toledo, Ohio.

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DESK TOP TRAINING AND FULL SCOPE SIMULATION

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1. ABSTRACT

In most peoples minds simulators are associated with aircraft and pilot training. Simulators are however not confined to aircraft alone but may be applied to any process that can be modelled mathematically.

Simulators have successfully been employed for operator-training requirements in oil and gas processing, fossil and nuclear fuelled Power Generation, Submarines and Ship Machinery Control Rooms.

This paper discusses the requirements for full scope Replica Marine Simulators, their advantages and limitations and how the latter can be overcome by Desk Top Training with its low cost ability to enhance the training package.

Examples of the integration of Computer-Based Training and Full Scope Replica Simulation are given by reference to two major Royal Naval Trainers.

The first concentrates on the Type 23 Frigate, it identifies the problems of providing maintenance training, and describes a solution to reduce the scope of replica hardware.

The second, is based on the Single Role Minehunter and the classroom concept for training, where even greater use is made of CBT.

2. FULL SCOPE REPLICA SIMULATION

2.1 Requirement

Trials and observation over a number of years have indicated that simulation in the Marine Training Environment has enhanced the individual skills of personnel in the operation and understanding of Ship Borne Systems.

The initial reasoning for shore-based training resulted from both logistic and financial reasons. Rising running costs, coupled with the reduction of ships in the Fleet, reduced the availability of vessels to be released for dedicated procedural training. This was aggravated by the risk of damage to the ship and its machinery, resulting from the mal-operation of equipment. Most accidents can be traced to operator error. The wrong action at the right time, the right action at the wrong time

or even misinterpreting commands can all end with disastrous results not only for those inside the ship but also to ships and their crews in the surrounding area, as illustrated in Figure 1.

The requirement for trainers has become more apparent as a result of the ever increasing complexity of Platform systems employing State of the Art techniques and the centralisation of the associated control and monitoring facilities into one discrete console and compartment in the ship. Classroom training, while able to demonstrate the principles involved, cannot train operators to react quickly and concisely in an emergency.

For these reasons, Full Scope replica simulators have long been considered appropriate for the majority of training requirements for Operational Staff on Machinery Controls and Surveillance Systems (MCAS) installed in Royal Navy Ships.

2.2 Advantages

Modern replica training simulators provide a high degree of fidelity, resembling and responding as precisely as Ship fit equipments and systems. They supplement classroom training with "hands-on" experience, providing trainees with an authentic environment in which to practice, either individually or as part of a team, the exacting procedural skills required to master the complex interaction between man and machine in intense and sometimes hostile surroundings.

The requirement for shore-based training which allows students gradually to gain confidence and experience of their operator tasks and objectives, is satisfied by the facilities provided by the Full Scope Replica Simulator. Experienced operators also benefit from continuation training in a simulator which increases their levels of skill, confidence and awareness.

Marine Defence Simulators are usually designed to last the life time of the ships they support, and can be used to train new operators, upgrade qualified operators to higher levels of responsibility, and run refresher courses and procedural training associated with normal, abnormal and emergency conditions of Ship and Machinery.

Some gain can be made in new ship-build programmes where the simulator is commissioned before the first of class, and used to confirm manning levels, operators grades and tasks, and also assisting in system trials and commissioning. This was demonstrated by Yarrow Shipbuilders who were able to train their engineers on Machinery operating procedures prior to commencing Sea Trials for Type 23 Frigate 01 due to the trainer being in advance of the Ship.

Additionally, the design of control systems algorithms can be validated against Dynamic Models of Machinery and Plant. This is especially evident when whole system, rather than its individual elements, is simulated. Further more, the design of the simulator itself draws upon the expertise of both engineer and user often with beneficial spin-offs for real ship equipment and systems.

It would be wrong to proceed, however, without a word of caution; the training simulator is a very powerful device, the potential of which can be readily negated by ill use. However, the instructor is in control at all times, and, well researched and

fig.1: "COMMAND MISINTERPRETATION."

carefully constructed exercises enable students to receive the correct training ensuring that they transfer from classroom to ship in the minimum of time.

Changes such as the availability of more accurate data on ship and systems, dynamic performance and the development and alteration of equipment can be readily and cost effectively achieved provided they relate to software only.

2.3 Limitations

Operationally, the Modern Marine Simulator is complete in its effectiveness. Noteable exceptions to this are the lack of maintenance and fault finding facilities. Maintainer-training requires its own form of "Full Scope" simulation. However, the traditional Full Scope simulator emulates the equipment to be maintained, and thus precludes the use of the simulator for maintainer-training. The alternative is to configure the simulator to include the maintained equipment. This is stimulation and supports some degree of maintainer-training, but it is far from ideal because of the limitations affecting the introduction of faults.

Usually, malfunctions are introduced prior to the start of the training exercise, by replacing items of equipment with equivalent hardware containing suitable faults. This tends to restrict the range of malfunctions which are available. If it is required that faults are initiated once the exercise is in progress, modifications and additional wiring must be provided, and inevitably this will destroy the realism of the training. Indeed, far from being a super sleuth, one is led by the nose to the problem area!

Insertion of malfunction by substitution also tends to apply economic limits to the number of faults available to the instructor, especially when whole system simulation is involved. Because of these fundamental difficulties, it was necessary to replace the use of real hardware with a more flexible approach for the provision of Maintenance training.

2.4 Fidelity

As we shall discover the maintenance trainer can be seen as a significant clue, with implications on general strategy for other types of simulators. It is important not to accept too readily the reasoning that replica presentation is best, without at least questioning its validity.

In particular, fidelity is a costly design ideal, a state of perfection which we strive to achieve. Though it may seem to be evident that "best" fidelity results in "best" training, there is little proof at present to support this. Any such measurements of training-effectiveness would require populations of inexperienced trainees with means, independent of the simulators used for assessing performance improvement. In consequence, tests of this nature are seldom performed. Those which are carried out, usually produce specific conclusions related only to the simulator used, without providing any general implications.

Past training has therefore tended to employ simulators which are realistic in style, even though this may not have been an essential requirement. In circumstances where some doubt existed, the balance has been more or less tipped by the fact that mere proficiency checking has been mistaken for actual training. Whilst students may be

happy to exercise in conditions which do not appear to portray realistically the working environment, they are likely to complain if their performance is measured in such conditions. However, in most machinery control, trainer applications, more emphasis is placed on improving, rather than assessing, the trainees performance.

3. DESK TOP TRAINING TO SUPPORT AND ENHANCE FULL SCOPE SIMULATORS

3.1 Visual Display Units

We have seen that maintenance trainers suffer from the problem of representation. Obviously the authenticity of real equipment would be most welcome, but this realism can often limit the range of malfunctions which can be exercised.

The ideal solution to the training requirement is probably a compromise between actual and facsimile equipment. Sufficient training should employ real equipment so that the trainees are familiar with its handling and appearance, and the remainder of the training making use of a more flexible medium.

Visual display units (VDU) have long been used in the training environment for the presentation of computer generated graphics, and as we shall see shortly, have provided a unique solution to the training requirements of two major simulator projects for the British Royal Navy.

From the students point of view, the exact medium employed may not be of importance, providing that the realism portrayed by the graphical representation is sufficient to support the training objectives.

3.2 Computer Based Training

Computer Based Training (CBT) techniques employing advanced hardware, software and authoring systems linked to dynamic simulation models, provide a most cost-effective solution for a wide range of training requirements.

The significant step in the introduction of CBT is the amount of freedom imported by the VDU in the "glass fronted" approach to equipment presentation. In most types of simulators the use of VDU(s) introduces a totally new freedom to both the format of the trainer and to the training it can provide.

3.3 Display Techniques

Initially, this appears to be merely a freedom of display format. For example we could simply mimic the real equipment by displaying a realistic replica of a control panel with touch-activation of the controls.

Alternatively, it may be preferable to display a schematic of the system, again with touch-activated control of the various elements. The schematic diagram serves as a reminder of the system configuration, which may not be obvious from the front panel layout. Animation can serve to enhance this facility, providing an instantaneous dynamic status of the system to the operator.

The display format is not arrived at arbitrarily but derived by addressing and assessing the training objectives to be achieved with due regard to established learning processes as follows:

* Gaining attention
* Informing Student of Objective
* Stimulating Recall of Prerequisite Skills
* Providing Learning Guidance
* Eliciting Performance
* Providing Feedback
* Assessing Performance
* Enhancing Retention and Transfer

We can now see that the simulation is no longer limited to the provision of familiarisation and operating practice but can be extended to include student instruction, self teach or Instructor led routines.

3.4 Degree of Freedom

The above ideas can be extended to identify three stages for capitalising on the freedom offered by VDU style presentation:

Firstly, there are many more data display formats which can be of potential benefit to the trainees, and they are mainly graphical representations. The most common are possibly time history plots but many other displays, such as the temperature or pressure through the length of a fluid pipe system, could be of equal use.

Secondly, this freedom of display format introduces the need for some intelligence. At a minimum, the system must offer the Student and/or the Instructor the choice of which display style is required. Alternatively, it may be sufficiently intelligent to automate this process and display whatever the training plan considers is of importance in the prevailing circumstances.

Thirdly, it is a natural step to develop this intelligence until the system itself can provide instruction in a controlled format. This is now a lesson and the simulator has now become combined with Computer Based Training.

3.5 Enhancement

The addition of Desk Top Training allows greater flexibility, whilst reducing overall simulator costs, by keeping the hardware requirement to a minimum and reducing production and installation times.

Alterations and additions to the ship systems can be readily and cost-effectively

accommodated with minimum disruption to the training programme, and this is of significant value when the trainer is in service before the ship. This flexibility in approach allows users with varying backgrounds and aptitudes to be trained, thus achieving maximum use of the simulator.

4 FULL SCOPE SIMULATION AND COMPUTER-BASED TRAINING

4.1 First Steps

The first steps in the integration of a Defence-related, Marine Full Scope Simulator and Desk Top Training were taken by the Royal Navy for its Type 23 Frigate Machinery Controls and Surveillance (MCAS) Trainer. The trainer installed in HMS Sultan was commissioned at the end of 1988 and is designed to provide pre-training, continuous team training and acquaint-training for operators and maintainers of the revolutionary CODLAG propulsion system, in the following specific areas:

* The Marine Engineering Officer of the Watch (MEOOW) in carrying out his duties during all phases of operation in the Ship Control Centre (SCC).

* The Power Control Lever Operators; in the effective operation of the Power Control Levers in response to bridge telegraphs and revolution indicators.

* Outside Machinery Operators; in the operation at ancillary plant and emergency equipment remote from the SCC without supervision, and the rendering of status reports to the MEOOW.

* Maintainers; investigating faults in the D86 MCAS equipment and restoring operational effectiveness to meet priority requirements with the minimum of delay.

The complete trainer illustrated in Figure 2, comprises the MCAS Console and Supervisor's desk, Forward and Aft Secondary Electrical Control Panels (SECP's) Gas Turbine, Diesel Generator and Thyristor Electrical Propulsion Motor Local Control Panels.

The training objectives required that the major elements of the simulator looked and behaved as identically as the ship fit equipment, which, coupled to exacting mathematical Models of Systems and Machinery, resulted in a high degree of fidelity.

During the Product Definition Stage (PDS), the fundamental requirements for the trainer, identified two distinct areas of concern. The first of these involved the scope of outstation hardware, resulting from the requirement for Ship-wide simulation of the MCAS and Main Electrical Power System (MEPS). Secondly, emulation rather than stimulation, of the D86 Control System could result in the trainers failing to meet the expectations for Maintenance and Fault Finding Facilities.

These limitations were readily solved by the adoption of Visual Display Units (VDUs) as a presentation medium. A carefully researched study by Training Analysts, resulted in the adoption of VDU's employing touch screens as a cost effective solution to these problematic areas.

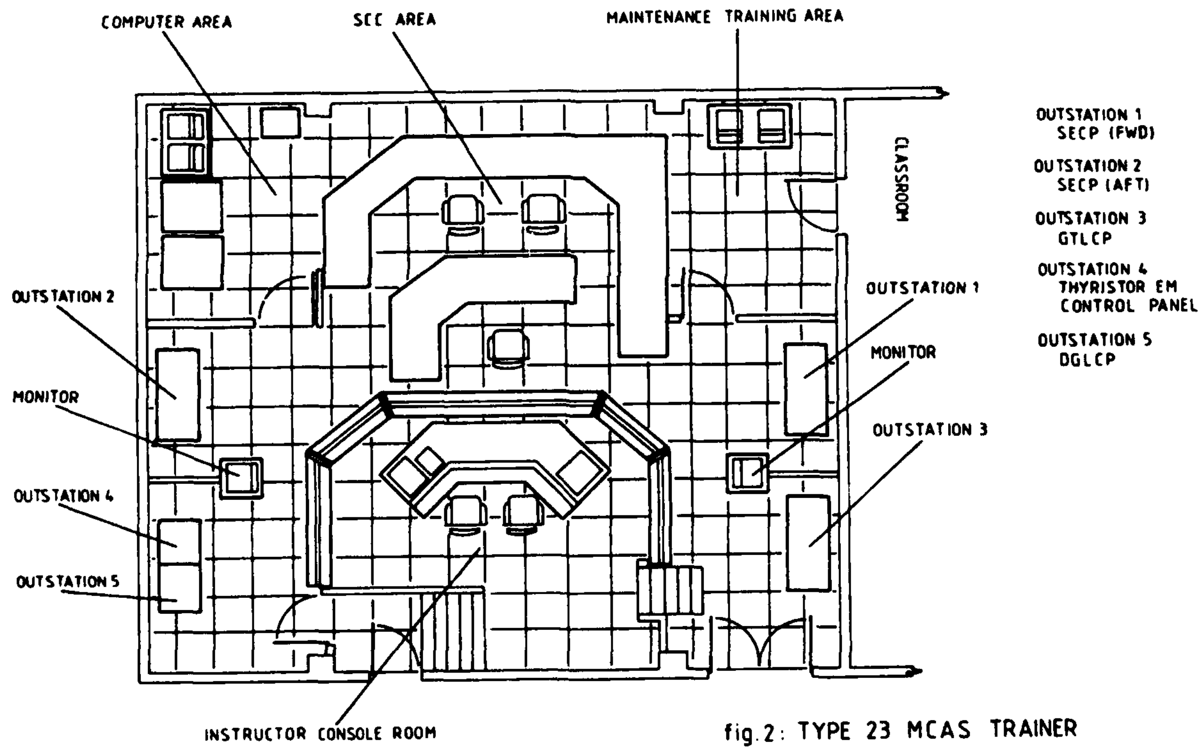


fig.2: TYPE 23 MCAS TRAINER

4.2 Manning Protocol

The Type 23 Frigate is designed for unmanned machinery space operation in peace time cruising and elevated NBCD states with Watchkeepers being dispatched from the SCC to the individual machinery space outstations as and when the need arises.

Similarly in the Type 23 MCAS trainer students are dispatched to the simulated machinery outstations to assume reversionary control or exercise investigative procedures on the digital controls and surveillance system as a consequence of the instructor set scenario.

4.3 Outstation VDU's

Unlike the ship the simulated machinery outstations are supported and controlled by two in number outstation VDU's with full touch screen capability.

The purpose of these outstation VDU's is to reduce by half the number of simulated machinery Local Control Panels (LCP's) associated with the Main and Auxiliary propulsion Machinery and provide an additional means for the management of auxiliary machinery systems which are not operable from the SCC.

4.4 Operation

With the exception of the Main Electrical Power System (MEPS), Secondary Electrical Control Panels (SECP's), the MCAS Local Control Panels are designed to be assigned by the outstation control VDU's to represent any system related panel.

Trainees for example, can assume local control, from the same Diesel Generator Local Control Panel (DGLCP), of any of the ships four Diesel Generators (DG's) by selection of the appropriate DG on the outstation VDU touch screen. Similar facilities are provided for the Gas Turbine (GT) and Electrical Propulsion Motor (EPM) LCP's.

Watchkeepers arriving at the Machinery Outstation VDU's are presented with a top level compartment location menu inviting them to touch select any one of the Type 23 Frigate Machinery Spaces, (UAMR, FAMR, GTR, MGR) where the training exercise is to be conducted.

Following touch selection of the required location the trainee operator is further presented with a lower level menu providing the choice of selecting either a system related Plant local Control Panel or an interactive schematic diagram of the vessels auxiliary machinery systems associated with that particular compartment.

4.5 Plant Selection

For example, selection of the Gas Turbine Room (GTR) at the appropriate outstation VDU will result in the trainee being given the choice of selecting between either of the Gas Turbine (GT) LCP's or any one of the Fuel Boost, Fuel Transfer, Lub Oil or Low Pressure Salt Water System interactive schematics.

Selection of GT No 1 will assign control and monitoring of the single simulator outstation GT Panel to the Stbd Spey Engine, with instantaneous display of the

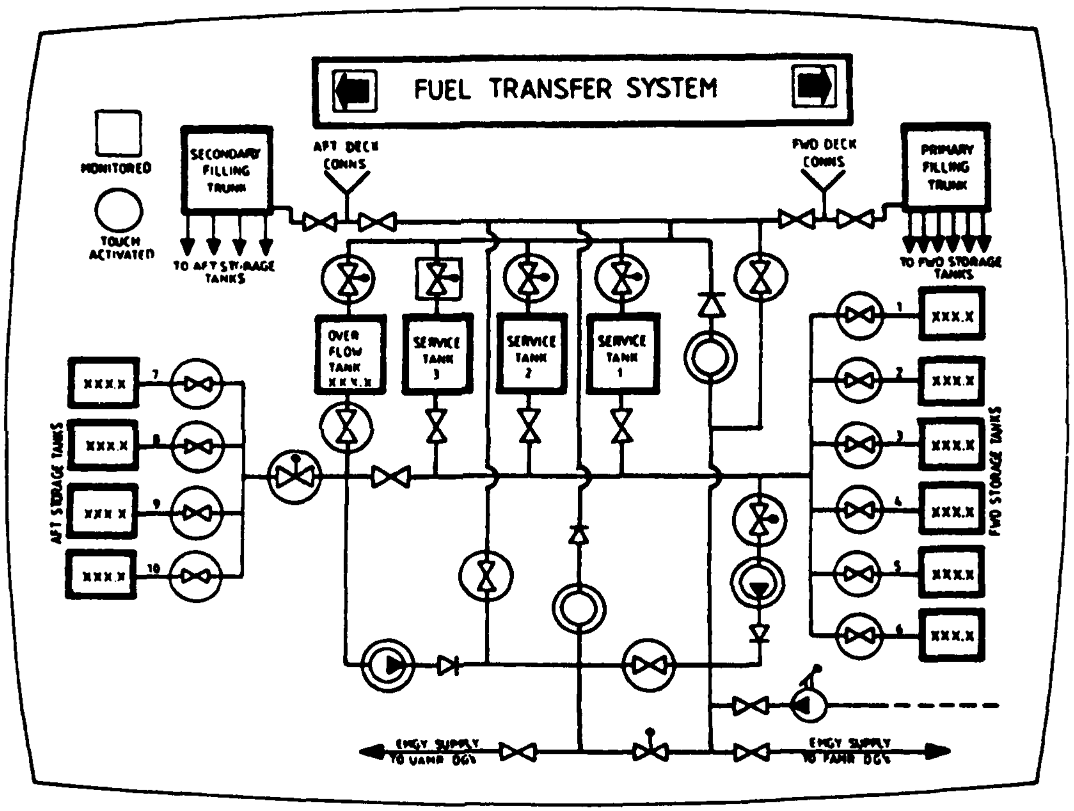


fig.3: FUEL TRANSFER SYSTEM PAGE

simulated Plant dynamic status on instrumentation and indication. Selection of either panel in a machinery space automatically inhibits Local Control and monitoring of the opposite machine thus control is not available until the detached watchkeeper has used the control VDU to select the machinery to be represented by the outstation hardware.

4.6 Schematic Selection

Selection of auxiliary machinery provides the Trainee operator at the outstation VDU with a high resolution interactive colour graphics schematic of the chosen system provided it relates to that Machinery Space.

Figure 3 illustrates the schematic diagram of the Fuel Transfer system available to operators at either of the four main machinery spaces. Touch activated starting and stopping of Pumps and opening and closing of valves allow trainees to exercise the efficient and effective transfer of fuel oil around the vessel; similar facilities are provided for the other auxiliary machinery systems.

In either mode the actions taken at the outstations by the trainees at Local Control Panels and interactive schematics are reflected in the system models running in the Simulator Host Computer.

Each Local Control Panel graphic contains a touch area for returning the display to the location selection menu. The departing trainee operator or the next arrival can then touch select in order to make a new choice of destination.

4.7 Maintenance Facility

The provision of the Maintenance Training and Fault Finding Facility proved to be a more significant problem which was exacerbated by the requirement for the emulation of the Vosper Thornycroft D86 Controls.

The actual maintenance training facility illustrated in Figure 4. comprises a Regency Z80 colour, graphics-based-training module incorporating Key boards, disc drives and twin, full colour, touch-sensitive displays for the presentation of both graphical information and courseware text. Using these techniques, students are presented with a very realistic graphical display of the real world equipment. A major factor in this is the colour capability of the high resolution 512 x 512 pixel screens, which allow the simultaneous selection of 16 colours. The associated touch capability, provides control via 4000 separate touch regions.

4.8 Operating Modes

The maintenance training facility provides for both, fault-finding and instructor-led training. The primary function of the fault-finding facility is the exercising of trainee maintainers in diagnostic techniques associated with the TYPE 23 MCAS and MEPS D86 digital control systems. A logical approach to investigative procedures through interaction with the touch screens was adopted and allows students to progress through discrete levels of fault-finding.

The maintenance facility is designed to operate in a combined or stand-alone

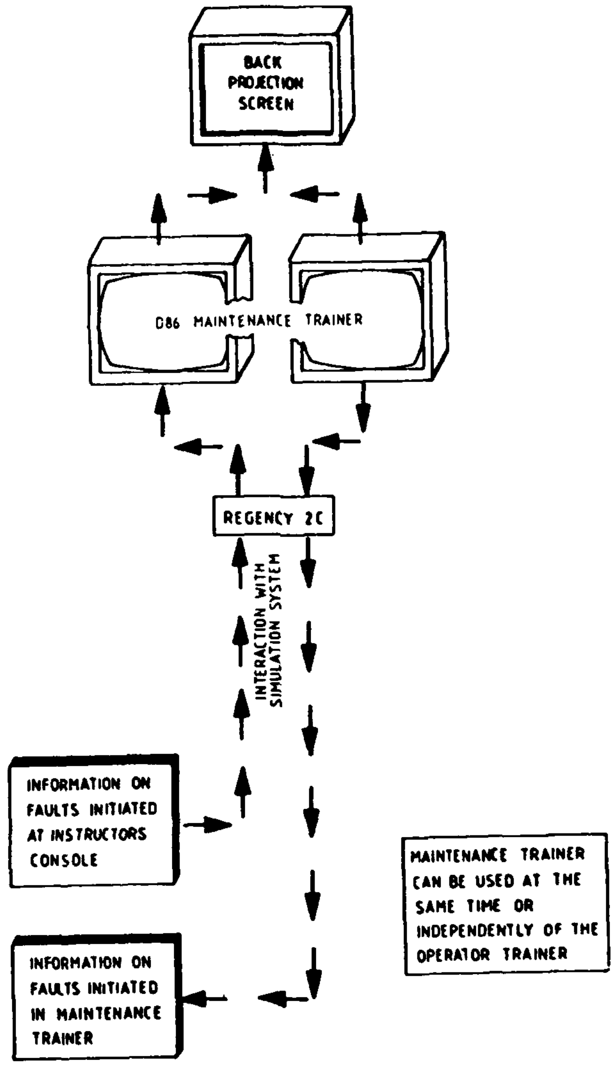


fig.4:MAINTENANCE TRAINER–SCHEMATIC

manner. In the *combined mode*, the *maintenance trainer* is linked to the main simulator host computer. The link is effectively one way, from Host to Regency, and enables the instructor to select one of the combined mode faults causing both simulator and maintenance trainer to manifest the symptoms of the fault. Operators can take action to accommodate the fault whilst maintaining control, leaving the maintainer to devote his attention to fault-location. The structure of the Regency Software portraying the D86 system is such that, whilst the maintainer follows his diagnostics procedures, the D86 network structure is also reinforced in his mind. In the stand alone mode the student interacts with the Regency only either as an individual or led by an Instructor.

4.9 Fault Diagnosis

Fault diagnosis features four discrete levels of training which commence with system, identification (MCAS/MEPS), followed by compartment location of the D86 rack (FER/AAMR etc), then D86 rack selection and finally, repair or replacement of Printed circuit boards (PCB's) or faulty wiring of systems-machinery transducers, and entails the trainee working between the Regency Main and Auxiliary screens. Initially on the auxiliary screen students are presented with the SCC fault related 'group warnings', secondary surveillance 'Plasma Display' and 'data logger' status information from which system identification is determined (MCAS/MEPS).

This is followed on the main screen by location of the affected D86 rack. The trainee is presented with top level plan view of the frigates Main and Auxiliary Machinery spaces including the SCC and Main Switchboard rooms and invited to identify the requisite compartment (FER, AAMR etc). Following Compartment location the trainee is presented on the Main Screen with a detailed Large Scale arrangement of the selected machinery space complete with Main and Auxiliary equipment which the student touch explores until he succeeds in identifying the position of the required D86 rack.

Rack selection is followed by the graphical presentation on the Main screen of the Machinery Local Control Panel containing the D86 Rack. Trainees are required to touch release the panel fastners and remove the cabinet door to gain access to the interior. On entry to the panel the Main displays graphics change to portray the D86 rack complete with Processor Card and individual Printed Circuit Boards (PCB's). Simultaneously the auxiliary screen graphics change to display the manufacturers diagnostics handset which the trainee touch operates to integrate the D86 rack and subsequently identify and rectify the fault.

Rectification includes the *repair or replacement of Printed Circuit Boards or Faulty* wiring of systems - machinery transducers. At all times simple inhibits prevent the student progressing to the next stage of repair should he depart from set procedures. For example the removal of a PCB is inhibited until the rack is powered down, and rack recommissioning is prevented until processor and diagnostic resets have been activated.

4.10 Classroom Aids

Enhanced, instructor-led classroom training is provided by back screen projection driven by the Regency System, and provides a single instructor with a large screen

display of the Maintenance trainer courseware, for use as a classroom aid. The courseware provides animated sequences under the control of the instructor by means of the Regency touch screens, enabling display of the functional elements of the Type 23 D86 controls and surveillance system.

In addition, systems foundation knowledge, with an example of the Ships Fuel Boost System, is also provided. This facility will eventually be expanded to provide familiarisation of machinery space layouts and animated system schematics.

5. SINGLE ROLE MINEHUNTER

5.1 Classroom Concept

Rediffusion's Royal Navy Single Role Minehunter (SRMH) MCAS trainer is based on a classroom concept. This unique approach employing even further Computer Based Training techniques and a large Screen Display, allows both trainees and additional Students to participate in the training exercise, under the control of a single instructor.

The trainer, due for delivery in early 1991 will be installed in HMS Sultan and is designed to provide Marine Engineering personnel with training in:

* Normal operation, control and surveillance of the Propulsion and auxiliary Machinery, Generation Machinery and Hotel services.
* Normal Watchkeeping duties with emphasis on response to Fire and Flood Alarms
* Reversionary control procedures in the event of Machinery control system failure.
* Diagnostic procedures associated with maintenance tasks for special to type aspects of the SRMH MCAS system.
* Foundation knowledge training for a wide range of Skills and Ranks.

In addition, acquaint-training for Commanding Officers (CO's) and Navigating Officers (NO's) in the propulsion machinery layout and its manoeuvring implications will be provided.

5.2 Training Analysis

Following a detailed training analysis, the proposed solution was arrived at by considering, in the light of the training options identified in Figure 5, the training value to be gained by each aspect of the proposed trainer balanced against the cost of implementation.

The results of the in-depth analysis identified common areas of skill training and allowed the adoption of a core approach for all student types, resulting in substantial savings of time effort and resources to be made, providing the training objectives were well defined.

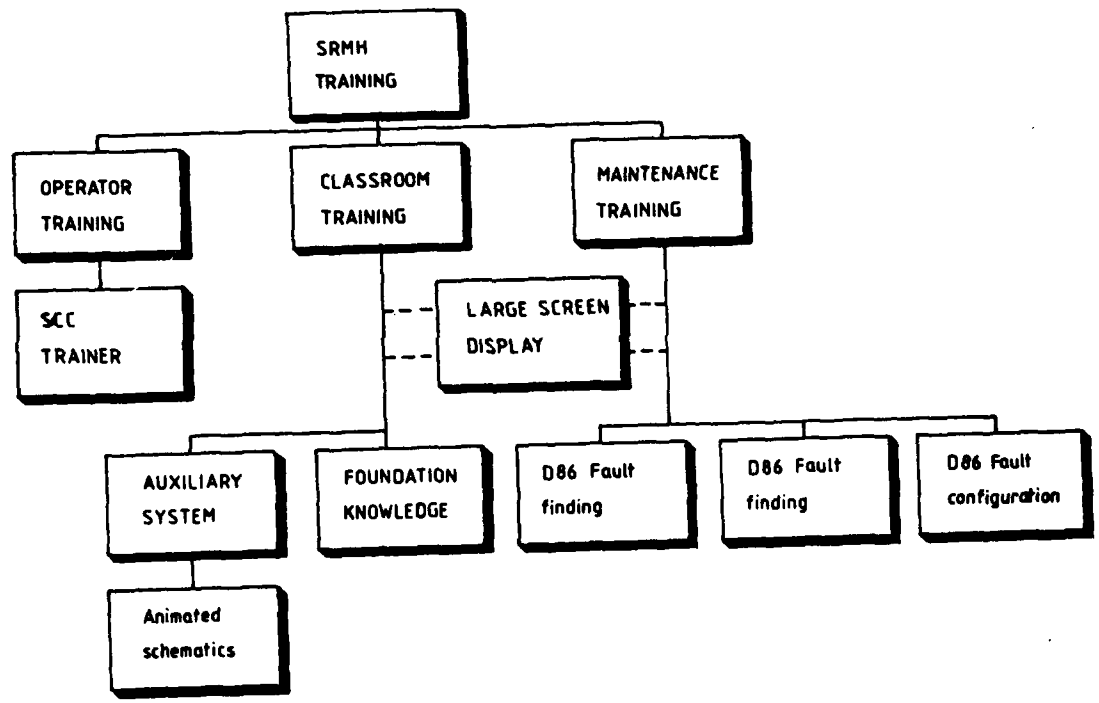


fig. 5: SRMH TRAINING OPTIONS

Close consultation with the Ministry of Defence Procurement Executive (MOD(PE)) revealed that the Training objectives could be split into three discrete requirements:

* Critical - directly affecting the safety of the ship in an immediate manner (the ability to operate the propulsion system).

* Operational - affecting the operational ability of the ship, but not directly affecting its safety, in an immediate manner (The provision of shore supply)

* Ancillary - affecting the ship's services in a manner which does not lead to a degradation of the operational capacity (The operation of the sewage plant).

5.3 Critical Objectives

Manual Operation control and surveillance of the propulsion and auxiliary machinery, electrical generation and Hotel services were identified as 'Critical' objectives for SRMH Students. These were divided into two necessary but complementary areas: system knowledge requiring classroom training and procedural actions requiring access to the simulator.

Reversionary modes of operation were identified at an early stage as critical Procedural Routines to be practised by all personnel. Further studies and reviews of the tasks revealed that the 'OPERATIONAL' training objectives necessitated a considerable amount of detailed learning by all levels of students. These connected activities would not be applied as abstract routines, but would be deeply embedded in the procedural activities required by the crew. It was obvious that the instructor would require simultaneous access to both a classroom and trainer.

The SRMH is a first of type, and will require students to acquire detailed knowledge in order to respond to routine and emergency procedures. These cognitive areas are a mixture of CRITICAL and OPERATIONAL objectives. This was especially evident for the Marine Engineering Officer (MEO) and the Marine Engineering Officer of the Watch (MEOOW), where detailed requirements were satisfied by the use of interactive system schematics integrated with the main simulator. In addition, the MEO has a major 'CRITICAL' maintenance task, and will be the only person on the ship with the necessary skills to be able to maintain and repair the D86 Based MCAS and Ship Positioning Control System (SPCS).

It was universally agreed during the Project Definition Phase that the main requirement of the trainer would be procedural, with limited environmental fidelity. This approach, which is proving to be successful, resulted in a cost-effective solution to the training objectives, provided that geographical realism relating to locality, remained uncompromised.

5.4 Classroom Layout

The complete classroom MCAS trainer illustrated in Figure 6, comprises the Machinery Control Console (MCC) and Main Switchboard in the Ship Control Centre (SCC) and Local Indication Panels (LIP's) at the Voith Schneider, Bow Thruster and Main Engine Rooms. The Instructor's station and the large screen display completes the

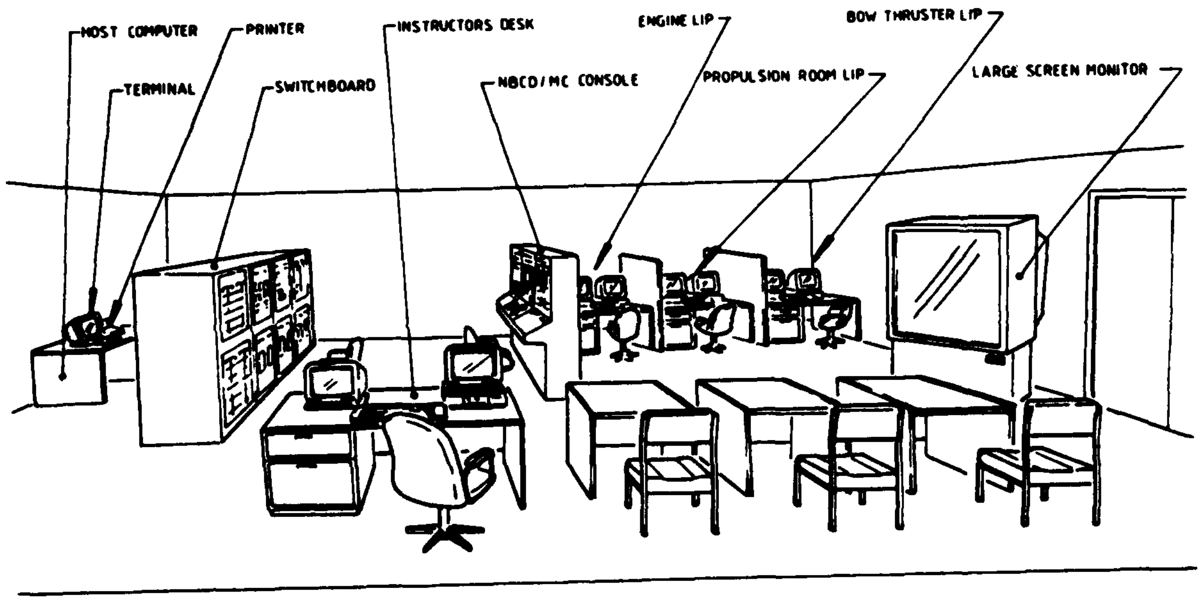


fig.6: SINGLE ROLE MINE HUNTER CLASSROOM CONCEPT

training facilities.

Ship's equipment is kept to a minimum, with the MCC and Main Switchboard in the SCC being the only items of hardware, replicating Ships fit equipment. Computer-Based Training Techniques are used to provide 'soft panels' at the three machinery outstations (Engine Room, Bow Thruster and Voith Schneider Propulsor Rooms). Here, IBM PC Compatible Computers, driving twin touch sensitive displays which employ high resolution colour graphics cards, coupled to full simulation models, provide detailed graphical presentations of both equipment and system schematics.

A key feature of the trainer is that the instructor may select any one of the outstation screens for presentation to a class on the large screen display, to give maximum visibility.

Design flexibility is of paramount importance, and when not engaged as machinery out stations, the PCs can be used for classroom training. This commonality of equipment allows each PC to hold the same software, thus providing an additional three student work station for classroom training. Software for both classroom training and Outstation Control is produced in the "TenCORE" authoring language.

5.5 Training Modes

The training modes provided by this highly innovative and flexible approach include:

* Full procedural Training with machinery outstations (combined)

* SCC Procedural Training with Individual training at the outstation PC's (stand alone)

* Instructor led classroom training with PC's and wide screen display, providing students with CBT courseware covering the following topics;

  Ship Foundation Knowledge

  Main and Auxiliary Propulsion Systems

  SRMH D86 Systems

  SRMH D86 Maintenance and Fault Finding.

During Full Procedural Machinery Control Scenarios, the outstations communicate with the Host Computer by data link. Panel arrangements and System schematics are driven by student inputs through the touch screen, in response to system models running in real time in the Host Computer. 'TenCore' routines are used to drive the graphics cards and the I/O handlers.

5.6 Flexibility

Figure 7 illustrated provisional graphics for the Voith Schneider Propulsor, local Control Schematics in conjunction with the VS Lub Oil System Control Panel. In

addition, figure 8 also illustrates the VS Local Panel. In this example, the Port and Starboard local panels are shown as overlays to the base panel. It may be more appropriate to represent these on the Second Screen, or alternatively to dedicate screens to port and starboard. The flexibility of the 'soft' approach allows details such as these, to be finalised at a later stage of the project.

5.7 Outstation Operation

At system initialisation the instructor assigns all or individual outstations to either CBT or full procedural training modes of operation as detailed in para 5.5 above. Selection of an outstation for full procedural training provides the trainee with the propulsion machinery related control panel on the main screen and a fully interactive auxiliary systems menu on the secondary screen.

On both the ship and the trainer the selection of Local Control at a particular machinery space LIP enables operators to exercise control over the associated propulsion plant. For example selecting local control of the Voith Schneider LIP in the trainer allows trainee's to assume control of the VS Propulsor and Lub Oil system and carry out reversionary control procedures as follows.

* By touch input, the trainee removes the steel pins from the linkage between activators and the VSP's.

* By touch input the trainee can then connect the Teleflex cable to either port or starboard VSP's, or both. The Teleflex cables for both lateral and longitudinal control are active at the soft panel.

* The trainee has touch control over the local VSP oil pumps which interact directly with the system model.

* Having connected the Teleflex cables, the trainee then assumes control of the lateral pitch by touch screen inputs to the handwheel and longitudinal pitch by touch inputs to the lever. Inputs are reflected changes in position of the handwheel and lever and also by means of a compass repeater located on the screen.

This soft panel approach provides a very flexible method of training operators in reversionary modes of control procedures, without the need to reproduce expensive hardware or complex cabled control systems.

The auxiliary systems module provides the trainee with the facility to display on the secondary screen any one of five fully Interactive Main and Auxiliary Machinery schematic diagrams.

* Fuel System

* DG ME LUB OIL

* HPSV

* Compressed Air

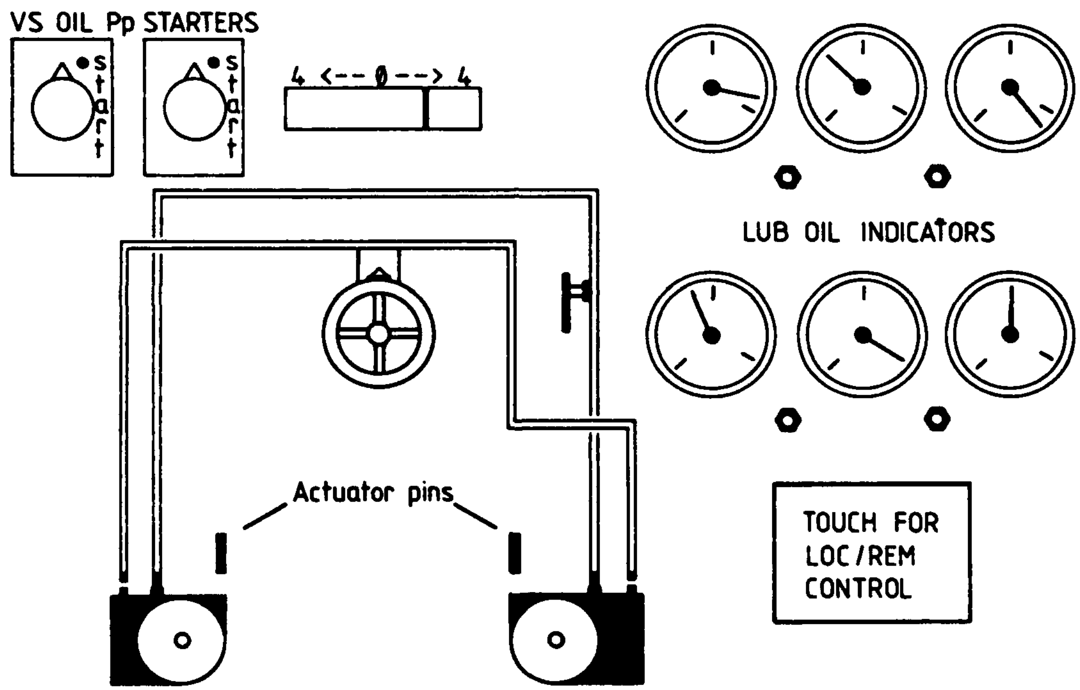


fig. 7: VSP SOFT PANEL

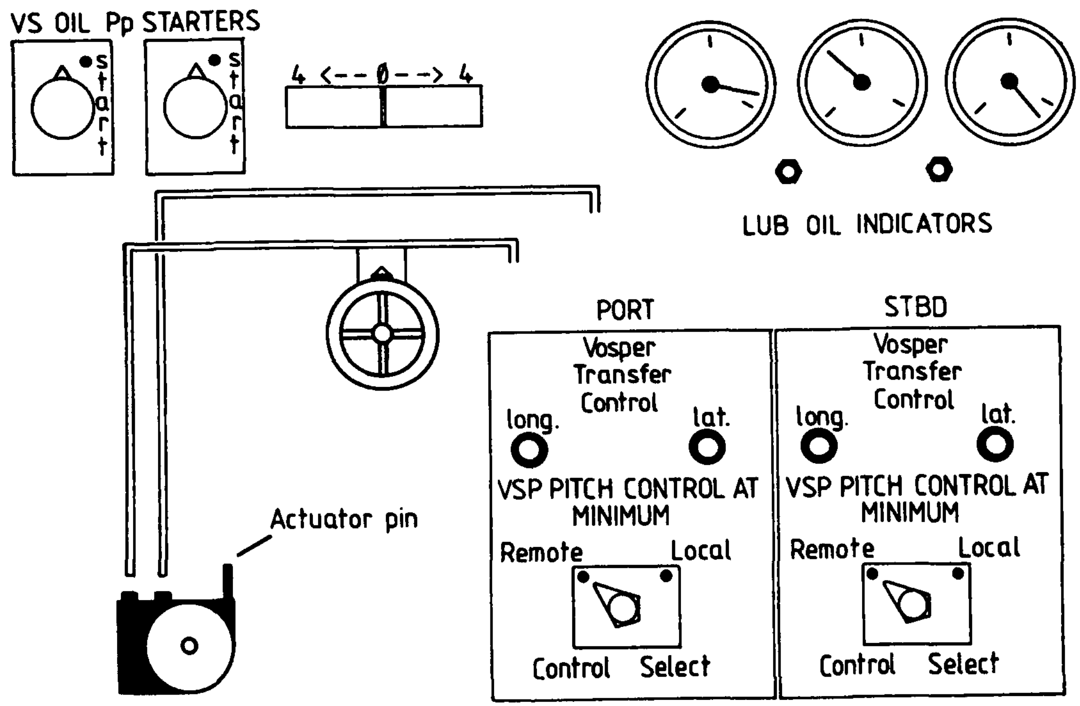


fig. 8 : VSP SOFT PANEL WITH CONTROL OVERLAY

* Propulsor

These interactive schematic diagrams are presented in a similar manner and technology as those on the Type 23 (Figure 3), with the facility for the outstation operator to exercise, by touch inputs control of the selected system. As before action on the soft panels by taken at the outstation LIP(s) and interactive system schematics are reflected in the system models running in the simulator host computer. Alternatively selection of all or individual outstations by the instructor provides trainees with access to the CBT courseware modules identified in paragraph 5.4 above and as described in the following sections.

5.8 Ship Foundation Knowledge

Ship acquaint on Compartment location and equipment identification is provided by the Foundation Knowledge Module which provides an overview of the SRMH compartment layouts, together with Deck plans of the machinery spaces.

Individual Machinery spaces, are presented in plan view on the Main Screen, using high resolution colour graphics. Essential equipment in these compartments is highlighted by student selection from touch-activated equipment menus on the auxiliary screens.

5.9 Maintenance and Fault Finding

A comprehensive Fault Finding Facility for maintenance training is also provided, based on the Type 23 D86 Maintainer Trainer, described in the previous section. This is supplemented with a highly animated D86 Configuration Module for use in the classroom mode.

The configuration module will be Instructor led and designed to enable SRMH Students to familiarise themselves with the following ship specific D86 equipment:

* An overview schematic of the SRMH D86 Rack Configuration

* Functional Descriptions of each D86 rack and SRMH specific PCB(s) within those racks.

* Overview of equipment serviced by the four racks including ship specific interface equipment.

5.10 SRMH D86 Systems

Training of the essential operational aspects of the SRMH system will enhance and support the lesson plans by using schematic diagrams of those systems, highlighted in the training analysis.

In addition, those schematics which support the CRITICAL training, objectives will be animated to provide a more dynamic training aid. The provision of descriptive material and additional animated diagrams relevant to the SRMH systems, will augment the animated schematics. This option is essentially Instructor-led, but can be

used in a self-teach, mode, controlled by operation of sequential text menu's, running on the Instructors console or outstation PC(s) covering the following critical systems:

* Fuel Filling/Transfer system
* Fuel Supply Systems
* Propulsion System
* Lub Oil filling, transfer and drainage system
* Compressed Air System
* Electrical Supply and distribution
* NBCD and Firefighting

The SRMH MCAS trainer will be a significant step towards the universal simulator. The 'Soft fronted' approach provides the customer with the unique classroom-based solution, fulfilling the training requirements, whilst permitting the Instructor to demonstrate the distinctive ship fit.

This approach has resulted in a simplistic, effective and flexible solution to the training requirement that necessitates the use of a single classroom, saves time in installation, fitting and maintenance, cuts costs and increases availability, whilst achieving the Training Requirements.

6. CONCLUSION

Simulator presentation is expected to move towards the use of VDU equipment instead of the traditional replica panels. This should not be seen as a compromise to be accepted reluctantly in obedience to the demands of cost reduction. Rather, it is the key move which will free training from the restraints of traditional replica simulators. These do achieve impressive realism, but this is not a proven necessity and, they cannot provide types of training which require the presentation of additional information display formats, and above all they do little to support the instructor.

Modern panel-replica style VDU page formats can achieve exceedingly high standards of realism. At the same time, VDUs are equally capable of presenting all other styles of information about the system, and may also provide direct instruction.

This reasoning should be sufficient to convince both simulation engineers, and training experts of the advantages of using this system. They in turn, will need to convince the authorities who control the training equipment budgets. At this stage, the case for the glass-fronted simulator becomes difficult to resist.

For example, a machinery-control simulator could use an all-glass configuration. All the simulator hardware would be assembled from general purpose computing and display equipment. With the right software, this trainer could serve all the functions of a traditional replica simulator. It could also add many imaginative and forward

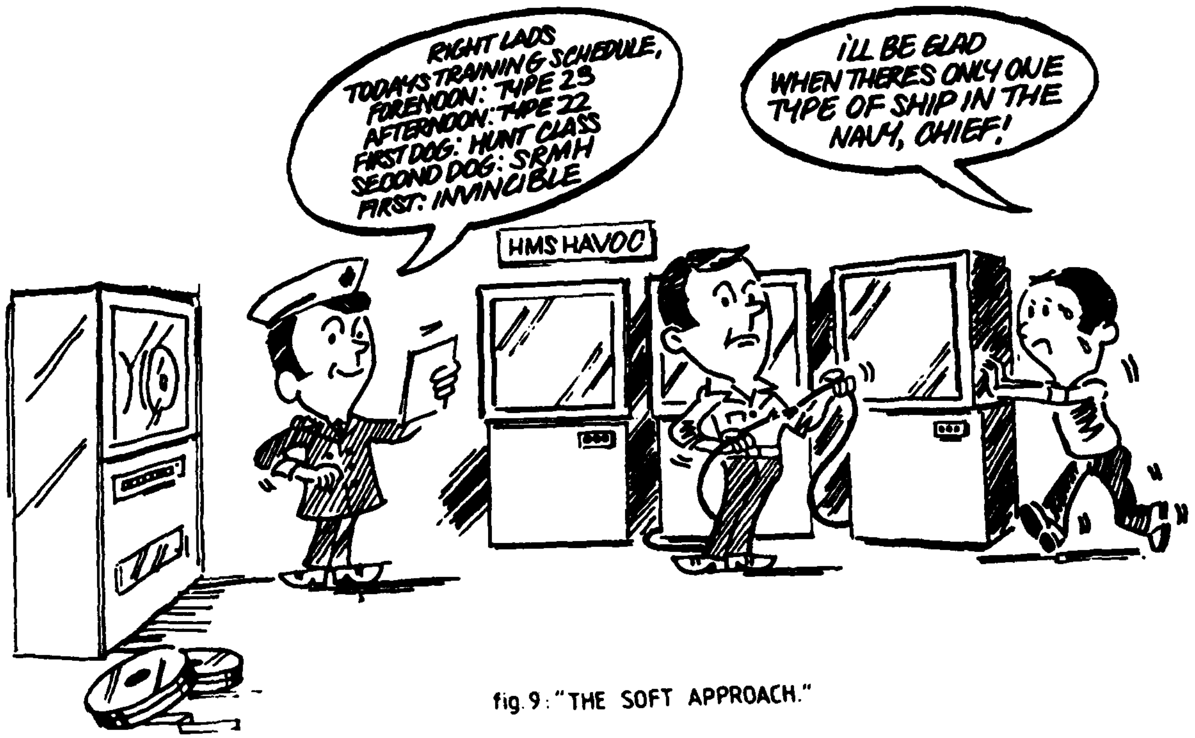


fig. 9: "THE SOFT APPROACH."

thinking features outside the capability of current trainers. However, the same hardware, with an alternative software set, could be converted in minutes to provide similar training for another ship-type as illustrated in Figure 9. The second, and any subsequent trainers could be supplied for about half the cost of procuring a traditional replica simulator.

Certainly, these additional trainers, co-habiting within the standard hardware set, are most likely to be machinery control trainers for other ship types. However, they could in fact provide almost any similar style of training required, at the same site. The main constraint of the supple approach to training will be availability, where training demand exceeds the facilities provided by a single suite of hardware.

A flexible system would include more than one set of standard hardware, each of which would be capable of running any one of a number of standard software packages. These would provide all the large scale artificial training required at that establishment. With careful planning, it would be possible to achieve the economic advantages of the very high utilisation of computing equipment.

References

Lt.Cdr. S.Trotter, MSC., RN 'TYPE 23 Machinery Controls and Surveillance Shore Training Facilities, J.NAV.ENG., 31(1), 1988

DESIGN AND DEVELOPMENT OF THE DDG 51 MACHINERY CONTROL SYSTEM TRAINER

by Stuart M. Williams
and Kenneth A. Lively
PDI CORP.

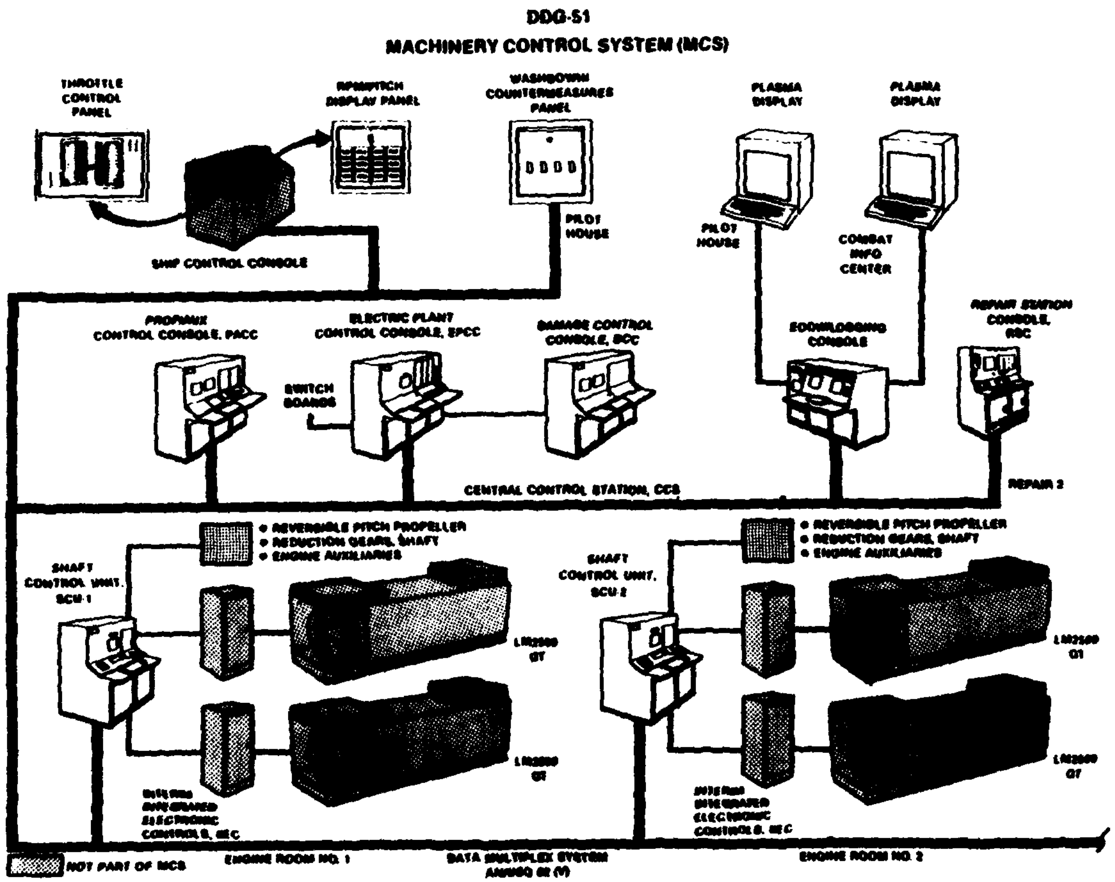
1. ABSTRACT

The need for a DDG 51 land based propulsion plant trainer was declared by the Chief of Naval Operations in early 1986. This paper traces the development of the trainer from initial concept formulation through delivery of the final product to the U.S. Navy's Engineering Systems School. The traditional differences between operations and maintenance trainers are compared with the architecture of the DDG 51 control system to show why actual shipboard consoles were used to form the console portion of the trainer. Synergistic ties to planning efforts for an embedded trainer and for a software life cycle support facility are explored to show the emergence of a "core requirements" philosophy that governed early design decisions. The architecture of the simulator/stimulator system is explained and the built-in capability for training by casualty and local operator action insertion is developed. The lessons learned during the modeling, hardware, and software development are explored. These include results of using Ada in a real-time environment and the solution for providing a digital interface between the DDG 51 control system's Data Multiplex System (DMS) and the commercial simulation/stimulation computers.

2. REQUIREMENT FOR TRAINER

2.1 Chief of Naval Operations Direction for Trainer Development

The DDG 51 Propulsion Plant is very similar to the gas turbine propulsion plant found in earlier gas turbine ships (DD 963, FFG 7, CG 47) in that it consists of two LM2500 gas turbines, a reduction gear, and a controllable pitch propeller per shaft. The Machinery Control System (MCS), however, differs markedly from earlier systems. It makes use of six (6) Navy Standard Microcomputers (AN/UYK-44 MRP) embedded in the 7 control system consoles, approximately 1200 Standard Electronic Modules (SEM) of relatively low complexity, gas-plasma flat screen displays for display of information to the operators, and redundant Navy Standard Power Supplies providing highly reliable input power. Additionally, two



DDG-51
MACHINERY CONTROL SYSTEM (MCS)
THROTTLE CONTROL PANEL
RPM/PITCH DISPLAY PANEL
WASHDOWN COUNTERMEASURES PANEL
PILOT HOUSE
PLASMA DISPLAY
PLASMA DISPLAY
PILOT HOUSE
COMBAT INFO CENTER
SHIP CONTROL CONSOLE
PROPULSION CONTROL CONSOLE, PACC
ELECTRIC PLANT CONTROL CONSOLE, EPCC
DAMAGE CONTROL CONSOLE, DCC
SWITCH BOARDS
EOOW/LOGGING CONSOLE
REPAIR STATION CONSOLE, RSC
REPAIR 2
CENTRAL CONTROL STATION, CCS
• REVERSIBLE PITCH PROPELLER
• REDUCTION GEARS, SHAFT
• ENGINE AUXILIARIES
SHAFT CONTROL UNIT, SCU-1
SHAFT CONTROL UNIT, SCU-2
LM2500 GT
INTEGRATED ELECTRONIC CONTROLS, IEC
NOT PART OF MCS
ENGINE ROOM NO. 1
DATA MULTIPLEX SYSTEM AN/USQ-82 (V)
ENGINE ROOM NO. 2

Figure 1.

new consoles appear for the first time - an Engineering Officer of the Watch/Logging Console located in the Central Control Station, and a Repair Station Console located in Repair II. Figure 1 depicts these components and the Data Multiplex System (DMS).

Early in 1986, nearly one year after contract award for the DDG 51, the Chief of Naval Operations (CNO) determined that the generic gas turbine training course then being planned for the Engineering Systems School at the Great Lakes Naval Training Center would not adequately train gas turbine specialists to operate and maintain the new MCS. Consequently, NAVSEA was directed to develop an MCS trainer.

2.2 Operator Trainer vs Maintenance Training Device

The DDG 51 ship construction contract required that the shipbuilder build two sets of MCS consoles, a ship set for the ship itself and a qualification set to be used for first article testing. At the time of the OPNAV direction regarding the development of an MCS Trainer, no plans existed for utilization of the qualification consoles following first article testing. Typically, a maintenance trainer consists of consoles identical to ship consoles in order to maximize realism in the training environment. Operator trainers, on the other hand, only require the front panel to be identical to the shipboard consoles and the expensive custom logic and signal conditioning electronics found inside earlier generation MCS consoles are frequently replaced with software executing on a commercial grade computer. Replacing expensive military qualified hardware by simulation is a much more cost effective solution. In the case of the DDG 51 MCS, however, most of the tactical hardware possess an architecture that is very nearly a militarized equivalent of a typical operator trainer. Since tactical hardware was "available", NAVSEA made the decision to use selected consoles from the qualification set as the basis for a combination operator-maintenance trainer.

The Central Control Station consoles used by the Gas Turbine Specialists (Propulsion and Auxiliary Control Console, Engineering Officer of the Watch/Logging Console, and the Electric Plant Control Console) were chosen as the Trainer configuration. These consoles are manned underway (the Shaft Control Units in the engineroom are not) and nearly all of the operator and maintenance interfaces for the entire MCS are represented. Furthermore, these consoles communicate with each other on the ship via a digital data bus (AN/USQ-82 Data Multiplexing System) so that the provision of simulated information was simplified, being a matter of developing the appropriate models and interfacing a computer to the bus. An exception to this is the Electric Plant Control Console which, although communicating with other consoles over the ship-wide data bus, has a hardwired interface to the electric plant generators and switchboards.

For maintenance training, consideration was given to the use of pre-faulted modules and to the utilization of fault insertion devices (FIDs). The Engineering Systems School instructors preferred pre-faulted modules, stating that FIDs would be detectable to the trainee during maintenance actions and would therefore detract somewhat from the realism of the course. Accordingly, NAVSEA decided early on to use pre-faulted modules and the maintenance training requirements quickly became a logistics concern with no impact on Trainer hardware or software development.

2.3 Trainee Through-put Requirements

Top readiness requires training of not only the initial core curriculum provided at the Engineering Systems School but also some type of periodic proficiency training following assignment to a ship. Operators of steam powered ships receive their proficiency training during actual ship operations via "BECCEs" (Basic Engineering Casualty Control Exercises). This is appropriate for steam ships since most of the operation is local hands-on manipulation of the final control element, with enclosed or central operating stations generally limited to monitoring and voice communications activities.

Gas turbine control systems, however, provide for both monitoring and control from a console, either local to the engineroom or remote at the central control station. This makes it possible to train the operator right at his watchstation, providing suitable simulated machinery signals can be provided to the console. In the case of the DD 963 and FFG 7 machinery control systems, many of the monitoring or control signals interfacing to the consoles are hardwired, making it quite expensive to provide simulated signals to actual ship consoles. Thus operator training for these control systems is restricted to shore-side installations using computer-driven training devices that appear on the outside to be control system consoles.

As mentioned above, the DDG 51 control system consoles already have an architecture similar to an operator training device. Not only does this make the tactical hardware well suited for use as an operator trainer, but it opens the possibility of providing proficiency training on board the ship using either embedded or on-board training concepts. The initial CNO concept for training of gas turbine specialists to operate the DDG 51 class MCS was for initial operator training (schoolhouse training) to be conducted at the Engineering Systems School and for proficiency training to be conducted on-board ship via embedded (or on-board) training. It was generally acknowledged that a single DDG 51 MCS trainer would not handle the student load since classroom procedures called for all students, regardless of which ship type they would be assigned, to be cycled through all of the trainers (FFG 7, DD 963, and the planned DDG 51).

Presently, the "throughput" problem for schoolhouse training is still unsolved, and no provisions have been made for the conduct of proficiency training. The former problem will likely be solved by either restructuring of the training course to send only DDG 51 bound students through the DDG 51 "lab", or the purchase of additional training equipment. The latter problem will be solved when a decision is reached regarding shore-based versus on-board training, followed by the procurement of appropriate equipment.

3. PLANNING PHASE

3.1 Parallel Developments

The decision to use a portion of the qualification set of DDG 51 MCS consoles for the MCS trainer led to a further decision to utilize a subset of the Data Multiplexing System (DMS) for console inter-communication. Again, a new procurement was not required since Engineering Development Model assets for the AN/USQ-82 DMS in use at NAVSSES Philadelphia could be made available to the trainer. Overlooking the Electric Plant Control Console interface for the moment, the remaining equipment required for the trainer consisted of appropriate computer resources implementing machinery models in software and controllable by an instructor. Not surprisingly, the same equipment, perhaps ruggedized or militarized, would also be required to implement an embedded training concept aboard DDG 51 class ships.

Meanwhile, the Computer Resources Life Cycle Maintenance Plan for the DDG 51 MCS computer software was starting to take shape. It called for software maintenance to be accomplished at NAVSSES Philadelphia using MCS consoles provided as part of the DDG 51 Gas Turbine Land Based Engineering Site (GTSLBES). The MCS consoles in conjunction with the "hot plant" portion of the GTSLBES would serve as a final test bed for any software changes prior to delivery to the fleet. A Digital Equipment VAX computer linked to an AN/UYK-44 MDS was planned as the software development station. Clearly, the hot plant equipment would not always be available or, if available, its use not always appropriate for initial testing of MCS software changes. Therefore, a simulation facility very similar to that envisioned for the land based or embedded training facilities would also be required at NAVSSES.

Since the GTSLBES simulation facility would not function as a trainer, but rather as an exhaustive test facility, it would differ from the Trainer in several critical ways. Most importantly, its interface to the MCS would be through the discrete and analog machinery inputs at the Shaft Control Units (SCUs) as opposed to a digital interface at the Propulsion/Auxiliary Control Console (PACC). This, coupled with an enhanced control over machinery plant parameters allows the test engineer to adequately exercise all operating modes and interdependencies for the entire MCS.

These three requirements for simulation/stimulation of DDG 51 Machinery Plant signals (Trainer, Embedded Training, and the NAVSSES Software Maintenance Facility) led NAVSEA to constrain initial design work such that a common core would exist that was suitable to all three projects. The Trainer was to be the first effort completed to support a ready for training date that would provide for training of DDG 52 and 53 crews at Great Lakes.

4. DESIGN DEVELOPMENT

Late in 1986 and during the first few months of 1987 the design of the trainer was quickly solidified. With the tight time constraint the decision was made to re-use existing math models developed for the DDG-51 dynamic response analysis during the contract design phase to the maximum extent possible. For the trainer unique simulator equipment the government directed that commercial off the shelf components be provided and custom hardware minimized. The selection of the computer system and language provoked the greatest debate amongst the combined Navy/industry team responsible for the trainer development.

4.1 System Engineering

Figure 2 shows an artist concept of the overall trainer configuration. Tactical machinery control consoles include the Propulsion Control Console (PACC), the Electric Plant Control Console (EPCC) and the Engineering Officer of the Watch (EOOW) console. Figure 3 is a schematic representation of the complete trainer system. A critical aspect of the overall system is that it combines both a digital network for passing control and monitoring signals and a "conventional" hardwired electric plant control system. This created two tough problems. The first was a difficult technical problem for the trainer design since the stimulated signals to the tactical EPCC had to exactly match the characteristics of the actual ships electrical and distribution systems or the console would not respond correctly. The second was the fact that the stimulation hardware had to exactly match the tactical hardware that itself was in a state of flux.

All control and monitoring signals for the propulsion and engineer's consoles (PACC and EOOW) are sent over the Data Multiplex System (DMS), which has the military designation AN/USQ-82. AN/UYK-44 computers in these consoles process the digital information sent over DMS. The network contains approximately 3000 parameters which can be processed to respond to operator actions. The bulk of this information is presented to the operators via the plasma displays with the number of individual meters and gauges purposely limited to truly vital systems. As previously mentioned, the exception to this is the electric plant control console. This console has a larger number of dials and gauges responding to over 300 hardwired signals.

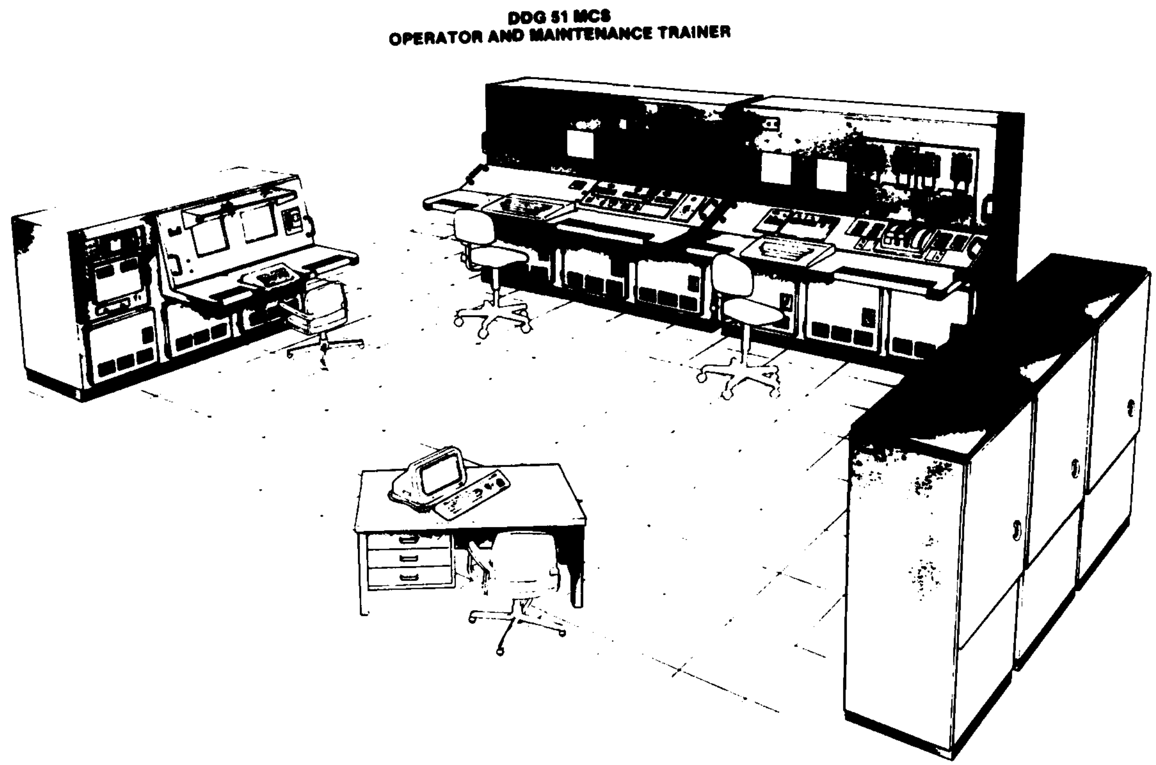


Figure 2. Trainer Artist Concept

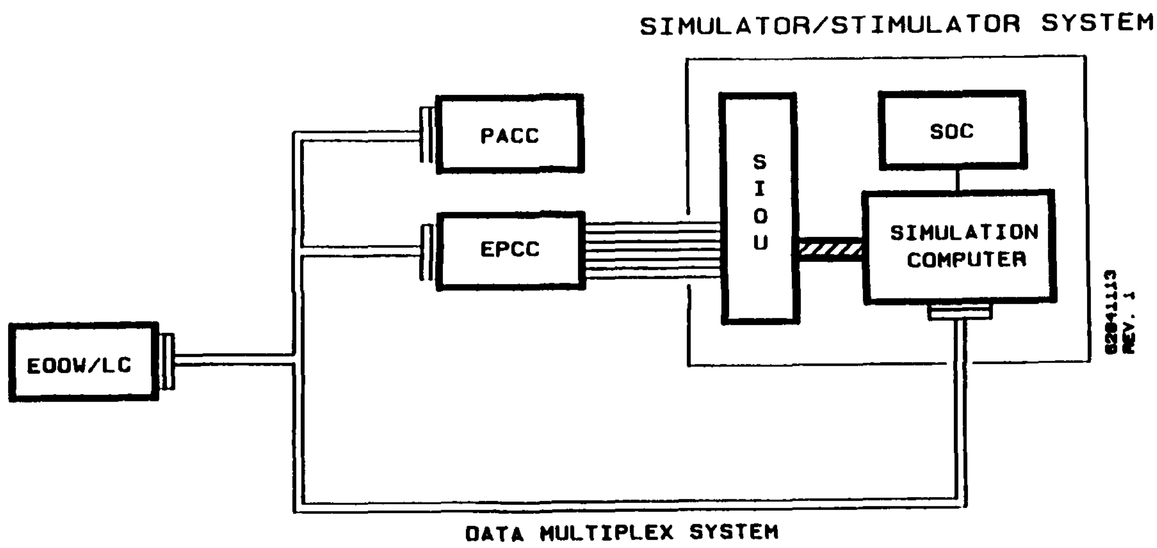


Figure 3. Trainer Schematic Representation

The trainer unique equipment consists of one cabinet with five Digital Equipment Corporation KA-620 processors and the interface to the DMS and two additional signal conditioning cabinets which create the 300+ hardwired signals the EPCC requires. Following the guidance to minimize developmental components, approximately half of the 100 required printed circuit boards were catalog items supplied by Computer Products Incorporated. These covered six of the eleven signal types that the EPCC needed, with the remaining five boards designed and built in house. The PDI unique boards are all associated with creating realistic sixty hertz sine waves so that the electric plant control console synchroscopes could be driven to provide realistic operator training. These boards respond to digital commands from the simulator computer updated at an eight hertz rate. Based upon integration testing with the tactical console this update rate appears completely satisfactory.

4.2 Software Architecture

This training device really represents the first time the conventional marine propulsion control training community has had to integrate with a software intensive control system. In reality this device combines three large software systems; the tactical consoles which each contain a program of approximately 12,000 lines written in CMS to DOD-STD 1679A, the DMS developed by Rockwell Autonetics, and the simulator/stimulator (SIM/STIM) with 50,000 lines of Ada code documented to DOD-STD 1679A. The SIM/STIM program debated whether to use FORTRAN or Ada as the development language. The final decision in favor of Ada was the strong argument that the lifecycle cost to maintain the software would be significantly lower. This was considered critically important because the trainer was being procured in parallel with the lead ship and numerous changes were anticipated. At the programs inception the size was estimated to be between 40,000 and 65,000 lines. Since this is a large real time program which had to work in lock step with the tactical control program the decision was made to match the documentation standard invoked for the tactical equipment. This was also in keeping with the Naval Training System Command's policy to document software to full DOD standards.

4.3 Modeling

With the total of approximately 3,000 parameters being passed over DMS, the DDG-51 control system has the flexibility to display an enormous amount of data. From the modeling view there is a tremendous amount of information to be generated. Table 1 lists the twenty-two Ada packages created to meet these requirements. The Table indicates the distribution of the software on the various processors and shows the build sequence during the integration phase. In general, for the major components like the LM-2500 gas turbines or the Allison 401K generators, existing models were adapted by reducing their complexity to allow them to be iterated

TABLE 1

ADA BUILD SEQUENCE BY FUNCTION

PROCESSOR	BUILD 1	BUILD 2	BUILD 3	BUILD 4
MASTER	TERMINAL DATA I/O REAL-TIME CLOCK MODE TRANSITION SCU 1/2 SCREEN INTERFACE BCU CONSOLE SIMULATOR	INITIALIZATION LOAD/LOG CASUALTY CONTROLLER LOCAL OPERATOR ACTION	DAMAGE CONTROL MODEL	DUMB DEVICE COMMUNICATION CONTROLLER DIAGNOSTIC
SHAFT 1	SCU-1 CONSOLE SIMULATOR SCU CONSOLE SIMULATOR	TABLE MANAGER DMS SEND/RECEIVE*	SHAFT - 1 MODELS	
SHAFT 2	SCU-2 CONSOLE SIMULATOR	TABLE MANAGER DMS SEND/RECEIVE	SHAFT - 2 MODELS	
ELECTRICAL DISTRIBUTION	HARDWARE SEND/RECEIVE EPCC COMMUNICATION CONTROLLER	TABLE MANAGER	ELECTRICAL DISTRIBUTION MODEL	
ELECTRICAL GENERATION	HARDWARE SEND/RECEIVE EPCC COMMUNICATION CONTROLLER	TABLE MANAGER	ELECTRICAL GENERATION MODEL	

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fast enough for a real time application. Where models did not exist, such as the lube oil system for the reduction gears, the entire system was modelled from first principles and the necessary parameters require for display were calculated.

Instructors at the Great Lakes Naval Training Center reviewed the system specifications and recommended the inclusion of certain casualties and local operator actions. Modifications made as a result of these comments allow the instructor to insert up to ten casualties from the list shown in Table 2. Local operator actions (LOA) can also be inserted by the instructor for activation at a specified simulation clock time. A good example of this is requiring the manual start-up of the electric fuel service pumps ten minutes into a training exercise. Table 3 lists a sample of the type of LOAs provided.

5. LESSONS LEARNED

Major projects share many common traits, one of which is that certain items envisioned to be complex and high risk in the beginning usually get solved because extra attention is focused on them, while some unknown jumps out in the middle of the project, potentially threatening completion. For this project a concentrated effort in the implementation of Ada caused that aspect of the project to proceed smoothly, while interface issues between the different hardware and software systems proved to be much more time consuming.

5.1 Ada in a Real- time Environment

One of the initial arguments used against going to Ada was that insufficient experience existed running Ada in a real time environment. Our experience has been that if you are careful in selecting a proven Ada compiler which has the proper real-time development tools available, then using Ada is certainly acceptable. Proven in this context means more than a certificate that the compiler passed its validation test. It means that the compiler has matured through several years of use by multiple companies. We actually asked for and checked out the "references" for each compiler we were considering by discussing the performance with companies who had already completed projects using the same system. In fact there are numerous airplanes, missiles and weapon systems which use Ada and have much higher update rates than were required for the DDG 51 MCS Trainer.

Figure 4 [1] has been used to show the differences between developing a large program in Ada or another language. Our project tracks with this curve very closely. Ada forces a clear requirements definition and then the allocation of Ada packages forces the interface between program elements to be highly structured. The big pay-off from this rather laborious initial

Table 2
List of Casualties

Propulsion Casualties

Module Fuel Valve Fail Closed
Fuel Filter Differential Pressure High
Fuel Service Pump Failure (mechanical)
Fuel purifier heater fault high/low
Lube Oil Purifier Trip
Lube Oil Attached Pump Failure
Lube Oil Electric Pump A Failure (electrical)
Lube Oil Cooler Failure (tube leakage)
Lube Oil Settling Tank Heater Regulator Failure High
Bleed Air Valve Fail Closed
Engine Ignition Failure
Engine Flame Out
Engine Starter Failure
GG Vibration High
Intake Icing
GTM Lube Supply Pump Failure
GTM Fan Failure
PT Overspeed
PT RPM Signal Loss
GT Lube Oil Cooler Failure (leak)
CRPP HOPM Failure
Pitch Response Fail
Pitch Sensor Fail
PT Brake Failure
Reduction Gear Journal Bearing F ailure

Electric Plant Casualties

GTG Lube Pump Failure
GTG Overspeed Trip
GTG Engine Bearing Failure
GTG Generator Bearing Failure
GTG Starter Motor Failure
Bus Tie Breaker Trip
Generator Breaker Trip
Generator Frequency Response Fail
Generator Voltage Response
Shore Power Breaker Trip
Bus Tie Breaker Response Fail
Generator Current Indication Fail High
Bus Tie Breaker Closed Indication Fail On
Generator Voltage Fail Low

Auxiliary System Casualties

Air Conditioning Plant Trip
Chilled Water Pump Failure
PRAIRIE/Masker Cooler Failure
Dehydrator Failure
Low Pressure Air Compressor Failure
Ship's Service Air System Rupture

Table 3

Local Operator Actions

a. SWBD local/remote control switch

b. fuel service pump controller local/remote switch

c. thrust bearing scavenge pump controller local/remote switch

d. turning gear engage/disengage

e. turning gear motor on/off

f. HOPM pump local/remote

g. seawater cooling pump controller local/remote

h. SSGTG engine local/remote switch

i. air conditioning plant local/remote switch

j. shore power breakers status-2S SWBD

k. shore power available

l. switchboard base load

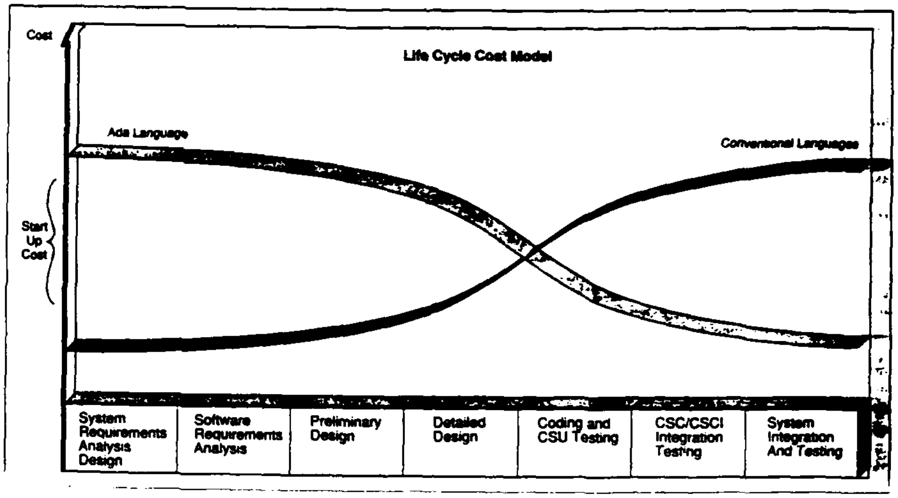

Figure 4. Software Development Phases

work is that the testing and integration phase go quickly, with only minor problems, and the life cycle is less costly since the requirements are very clearly documented.

5.2 <u>Data" Freeze" and Thaw</u>

As innocent as data management sounds, the reality is that this aspect of the trainer development consumed a tremendous amount of time and is absolutely essential to the success of a project like this that relies on multiple vendors for the various hardware and software. A data freeze date was established during the initial project plan to occur approximately one third of the way through the development. This milestone was religiously adhered to in order to allow sufficient time for the trainer unique simulator/stimulator design to mature and be tested. This approach has proven to be exactly the correct one since the tactical console's hardware and software continued in a state of flux. This should be recognized as a generic problem to be anticipated in any training device which follows a parallel development path with the actual system it emulates. This particular trainer benefitted from the DDG-51 Land Based Engineering Site (LBES) at NAVSSES. With the slip in the delivery of the lead ship, LBES assumed the role of system integration and check-out for the machinery control system. Since the LBES facility had both the PACC and EOOW consoles

available, early check out of DMS issues and validation of the content of the messages being passed between consoles was possible. Future machinery control systems which require a companion training device must provide for the earliest possible acquisition of any tactical equipment. The problem is the inherent focus on the lead ship at the expense of the trainer. For this trainer the tactical consoles are the sets bought as qualification units to test shock, EMI, etc. These consoles were delayed because of their developmental nature, which would have been a major problem except for the availability of the LBES consoles.

5.3 Interface to the Data Multiplex System (DMS)

When the initial decision was made to use commercial computers, one of the critical items checked was the availability of an interface between the selected computer and DMS. An industry survey revealed only one source of a printed circuit card which would interface directly between Digital's "Q Bus" and DMS. Upon placement of an order for the three required cards the manufacturer responded with an offer of a one year development at a cost an order of magnitude greater than their original estimate. After reviewing other avenues for securing the same device at lesser cost and with faster delivery, NAVSEA decided to have PDI develop the card. The result is a very robust card which can interface from any commercial standard computer bus to DMS. This was accomplished by providing a Digital Equipment Corporation DRV parallel interface to communicate to the commercial computer, then the translation to DMS takes place in software residing on the card's Intel 8088 processor. To match a different commercial computer simply requires different software on the card. For this application, surface mount technology was employed to shrink the necessary components onto the Digital standard sized printed circuit card.

5.4 Configuration Management (CM)

For a large software and hardware project configuration management cannot be overlooked. An active CM process should be budgeted for early in the project, and then followed consistently. This pays for itself especially in the software documentation area because of the extensive documentation required to satisfy DOD-STD 1679A or its successor 2167A.

6. CONCLUSION

6.1 Use of Ada

Despite initial concerns that the use of Ada presented an area of significant risk to the success of the Trainer development, it has proven to be an excellent choice as a real-time software development language. Both Ada and the DOD Standards governing software development require a considerable up-front investment in

requirements definition and development of program architecture. With Ada, this pays off with significant time savings during the integration phase.

6.2 Trainer Acquisition Scheduling

It is not possible to support training of the first (or even the second or third) crew even with a parallel trainer development program. Since the DDG 51 MCS represents a new generation control system, with development begun in May of 1985, most of the detailed technical data required as input for the trainer development was just completing the design stages at the time it was required. PDI found itself continually "chasing data" and ultimately instituted a data freeze concept in order to proceed towards trainer completion. PDI could not have started the Trainer any sooner - data simply would not have been available. The lead ship crew, by todays crew phasing approach, starts arriving at the ship 12 months prior to ship delivery. This leaves a very brief window for crew training (3-4 months) and this disappears if any schedule perturbations occur.

An important facet of a real-time simulation such as the DDG 51 MCS Trainer is the need to validate the model dynamics against the actual machinery being modelled. For the first ship of a class, data required to validate and fine tune the machinery models does not become available until after builder's trials. Therefore, a trainer acquisition program should plan for and accommodate a significant upgrade following ship trials.

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DESIGN AND CONSTRUCTION OF HIGH FACE VALIDITY SHIP CONTROL SIMULATORS FOR PROCEDURAL TRAINING

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1. ABSTRACT

As the complexity of naval and merchant ships increases, training requirements become more stringent, and are less able to be met by on-board training. It is now usual for simulators to be used for both bridge and machinery control training, and if these are to be used as procedural trainers, there is frequently a need for a high level of face validity to be achieved. This requirement is often met by using actual naval equipment, at a very high financial and logistic cost, linked to large computers.

This paper examines the requirement for *procedural trainers*, in terms of their training needs, and in the level of face validity actually required. Recent experiments on the validity of a range of visual systems of widely differing complexity are discussed, and methods of construction to give a high face validity of simulated controls and instrumentation, at a significantly lower cost than is incurred by the use of actual naval equipment, are demonstrated.

2. INTRODUCTION

Considerations of cost continue to dominate the thoughts of ship systems designers for both civil and military applications. For merchant ships the two most significant cost items have continued to those of crew and fuel. Over the past decade there have been many efforts to reduce these costs, some more successful than others. The efforts to reduce fuel costs have resulted in the predominance of slow speed diesel engines in deep sea ships, fuelled by high viscosity distillates. The use of single screws with large propellers has enabled outstanding cost reductions to be made, often at the expense of controllability, as many large, high sided ships cannot go slowly, or behave with adequate docility in a strong wind.

The efforts to reduce crew costs in merchant ship installations have resulted in ships sailing with crews often in single numbers. If these crew reductions are to be achieved in a responsible manner, (for example by not reducing bridge manning to the extent that the primary requirement to keep a good lookout cannot be reliably achieved), a significant measure of system redesign must be achieved. This is largely in the realms of monitoring and control, to enable those crew remaining to achieve a satisfactory level of knowledge on the state of the ship's machinery and the environment, and to be able to take adequate, informed action, usually from one or more centralised control positions.

As the crew levels reduce, the area of expertise of the remaining crew must be widened. This has long been achieved with ratings, where the GP rating is now commonplace. The ability of officers to achieve the necessarily high standard of knowledge over the whole range of ship operations has posed training authorities with a number of problems. Early attempts to achieve dual trained officers tended to fail, possibly because the need was not fully apparent at the time. The need is now fully apparent with a perceived worldwide shortage of adequately trained officers to man the remaining merchant ships.

In naval ships, the needs to achieve a level of economy in manning, and an increase in fuel efficiency are of similar priority, although usually for different reasons. Manning reductions are required to enable scarce space aboard ship to be deployed more effectively, and to compensate for the increasing difficulty in obtaining the necessary skill levels to man increasingly complex weapons and propulsion systems. Fuel efficiencies are needed both for financial reasons and because of the need to increase the endurance of surface units.

The ways in which economies are achieved are broadly parallel to those in the merchant surface. Officers and ratings have become more widely trained, with the user/maintainer concept being widespread. The increasing use of remotely controlled machinery has placed a very heavy reliance on effective monitoring and control arrangements, usually using distributed computing systems, (1), (2). Although one of the early aims of centralised control was to reduce the numbers of watchstanding personnel, this was not always achieved. The advantages of electronic centralised monitoring claimed by Benjamin, (2), are those of maintainability, training capability, reliability and ship energy efficiency, rather than those of direct crew reduction. Over the years however, the numbers of watchstanders in machinery spaces has been able to be decreased.

The large increase in complexity of modern warship machinery, navigation, weapons and control equipment, coupled with the achieved reduction in crew numbers, has placed strong emphasis on

training to achieve the necessary skills, usually of a procedural nature. It is necessary for watchstanders to be able to recognise a pattern of behaviour in their gauges or other indicators, and to take appropriate action, usually quickly and reliably. The necessary actions can range from assessing a dangerous combination of alarm indications in a machinery control and surveillance system to taking immediate action following a gyro alarm.

An increasingly widely used device to assist in the training of watchkeepers in their skills is the procedural simulator or trainer. This device will attempt to reproduce some or all of the user interfaces of a piece of control equipment, to give the user the necessary visual, aural and tactile cues, and to provide him with a means of taking the appropriate simulated response.

Simulators and trainers are provided at all levels of complexity and comprehensiveness, ranging from the full mission bridge or ops room simulator to the small part task maintenance trainer.

3. SIMULATORS AND TRAINERS - FIDELITY REQUIREMENTS

The cost of large, comprehensive training simulators can be very high. There is however no clear relationship between the fidelity of the simulator and its use as a training device. In a remarkably lucid paper, Andrews, (3) distinguishes between simulators, (which attempt to reproduce exactly a required aspect of the real world), and which may or may not be any use for training, and a trainer, which is optimised for the training task, and may not be particularly realistic as a simulator. A trainer will make use of a realistic cue only if there is a positive enhancement of the training process.

The training value of a trainer or simulator may therefore bear little relationship to the level of fidelity provided, particularly in the less critical areas of provision. It is to be regretted therefore that simulator procurement is made usually by those who are pleased to see a high level of face validity at all levels of provision, despite there being no perceived training need for the level of provision specified.

One of the most wasteful and expensive provisions frequently specified in ship's bridge simulators is the frequently quoted need for motion to be provided in the bridge. The need for physical motion platforms can be very rarely justified on any terms, particulary for a shiphandling or bridge training simulator. The one certain effect of specifying a motion platform is to increase the cost of the simulator by up to 50%. As there are at present no validated six degree of freedom mathematical ship manoeuvring models in existence worldwide for either naval or merchant ships, the accuracy of such a provision is suspect, and

the training need for such a provision is difficult therefore to justify.

The essential features of a training or procedural simulator are:

- the mathematical model of the system concerned
- the visual cues provided, (from gauges in the case of a machinery control console, or from a visual computer generated imagery scene in the case of a bridge trainer.
- the input/output devices provided for the trainer interface.

Each of these features will be examined in the light of experience in operating, designing and manufacturing a number of training and research simulators over the past decade. The aim of the examination will be to try to establish a meaningful minimum provision of expensive equipment, with the aim of avoiding overspecifying training equipment. In only one case, that of the bridge visual scene, has some quantitative research been carried out by the author. In other cases, the conclusions are made on the basis of extensive operational experience.

4. SYSTEM MATHEMATICAL MODELS

The aim of the mathematical model situated inside the simulator is to provide the essential relationship between the cues provided to the trainee and his responses. If the mathematical model is too simple, the responses will be atypical, or may simply be wrong, and there is a danger of training the wrong thing. If an over-specified model is provided, the cost will be more than would be necessary if the correct level of modelling were specified.

In an earlier paper, (4), the author distinguishes between ship manoeuvring model requirements for a simulator used for coastal passage planning, where there is no strong requirement for detailed accuracy, up to the problem of steering a ship down a heavy quartering sea, where there are few if any mathematical models capable of giving a fully realistic representation. The problem of berthing a ferry in wind conditions was quoted as being an achievable, but difficult task to get right for the mathematical modeller.

For machinery control simulators, it is usually necessary to be able to provide the trainee with a number of fault conditions, which need to be able to be able to be set by the instructor simultaneously, ideally with no limitation on the number and sequence of the faults. This situation is able to be achieved if the models are built to be a representation of "what is there", using first principles, rather than attempting to build up a complex system from steady state fits of manufacturers' data.

5. VISUAL CUES

It is in the representation of the visual scene from a ship's bridge that there is the greatest variety in level of provision. A Computer Generated Imagery visual scene can cost from about £5000 to £1m per visual channel, with several levels of provision in between. All will provide a range of visual cues for the mariner, and an ability to relate the own ship to the outside situation. It is necessary therefore for those tasked with procuring bridge simulators to be able to specify the level appropriate to the training task envisaged. If too high a level of provision is specified, the usual result is that the entire training device becomes too expensive for that year's allocation of funds, and so no training is achieved. This process is capable of being repeated each year indefinitely. The appropriate level of provision of a visual scene, along with the other aspects of the simulator, can achieve cost savings of over 50% in the total budget of the training device with no perceivable loss of training performance.

In a recent study, (5), of the ability of mariners to relate their ship's condition to the visual cues provided by a range of systems, a number of mariners were tested for their ability to determine their ship's position, speed, heading and rate of turn in a seagoing situation, in a simulator fitted with a high level of visual fidelity scene, and in a simulator fitted with a low level of fidelity of visual scene. The mariners were also tested in their ability to con the ship through a complex channel, again using the different levels of visual provision.

The main conclusion of the work was that there was no statistically significant difference in the abilities of the mariners to either detect the condition of their ship or to be able to con a ship using visual cues, using either of the two visual scenes or using the cues form the real world. One possible explanation of this somewhat surprising result is that mariners are not especially proficient at assessing speeds and distances in real life, and so are not significantly less proficient at the task when confronted by either a complex or simple simulated visual scene.

The mariners used for this study were all qualified to at least Second Mate standard. The study is therefore not necessarily relevant to a simulated visual scene used for initial training, where the trainees may not be able to relate to simpler visual scenes. It may however be concluded that care needs to be given when specifying the level of visual scene on grounds other than those of proven training need.

For machinery control simulation, the visual cues are presented to the mariner by a set of gauges or VDU displays. It is customary

with naval trainers to use actual equipment for this role. In a recent simulator provided for the Royal Navy, a helmsman trainer, the opportunity was taken to specify a device which did not attempt to use real equipment for the gauges or controls. A high level of face validity was assumed to be required, as the console was to be used for a very wide range of training, from initial familiarisation and training of new entrants, to conning practice for COs designate. The consoles provided, (Fig. 1), was able to be made using normal commercial methods, at a considerable cost saving over actual naval equipment. For example, in Fig. 2, it is seen that commercially available gears, meters and switches are used to produce a good facsimile of an Engine Order Transmitter.

6. INPUT/OUTPUT DEVICES

Similar arguments apply to the provision of controls for simulators. The use of actual shipboard equipment is often prohibitively expensive, and difficult to justify in terms of either financial cost or training effectiveness. Sometimes however, the use of shipboard standards of switches and joysticks is perceived to be necessary to give the correct appearance. in a recently supplied procedural simulator for the State Transit Authority of New South Wales, which was to represent a ferry manoeuvring console, it was decided, on largely cosmetic grounds, to supply the same standard of console equipment as is found in the actual ship. While not being fully justifiable on cost grounds, the justification was made on grounds of overall appearance, (Fig. 3.) Switches and controls which were readily available, (although usually able to be procured at prices less than one sixth of those of the actual equipment), were felt to be too dissimilar in feel or appearance.

In most cases however, particularly for naval equipment, the very large difference in cost between actual and facsimile equipment makes the decision easier to take in favour of facsimile equipment. The Pitch Control Levers, for example, of Fig. 1 are wholly synthetic, and can be produced at around 10% of the price of actual equipment.

7. CONCLUSIONS

The face validity requirements of simulators and trainers are not in all cases easy to define. Those responsible for the definition and specification of simulator based training equipment are not always best qualified to judge the appropriate level of provision required, and can, by over-specifying, cause the cost of a trainer to be un-necessarily increased.

There is considered to be a requirement for a greater awareness of what is actually required from a training needs point of view. For many training devices, what is required is a sufficient level of psychological fidelity, rather than physical fidelity, (6). in achieving psychological fidelity, only those cues actually associated with he training requirement are provided to a high standard, others being eliminated, or their provision greatly reduced.

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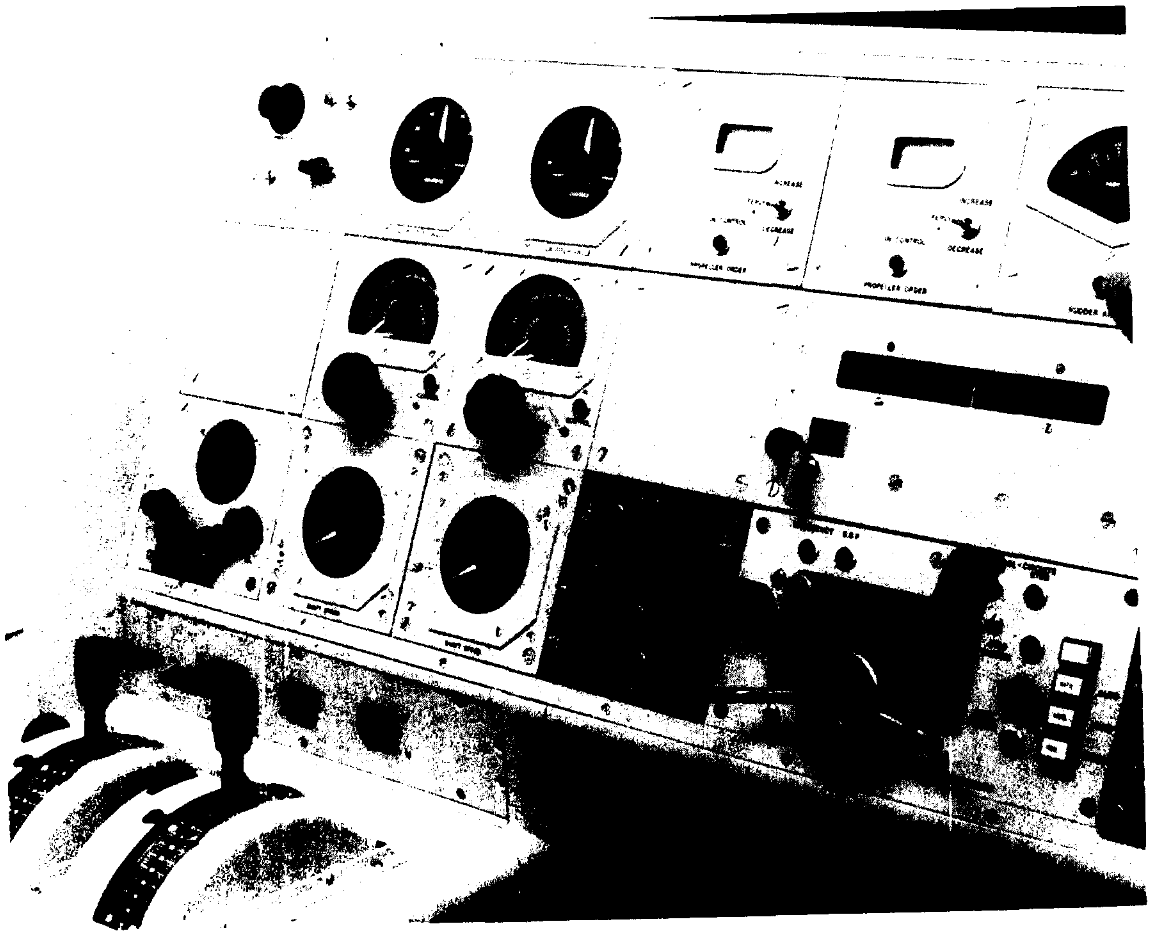

Figure 1. Royal Navy Helmsman Trainer, HMS RALEIGH

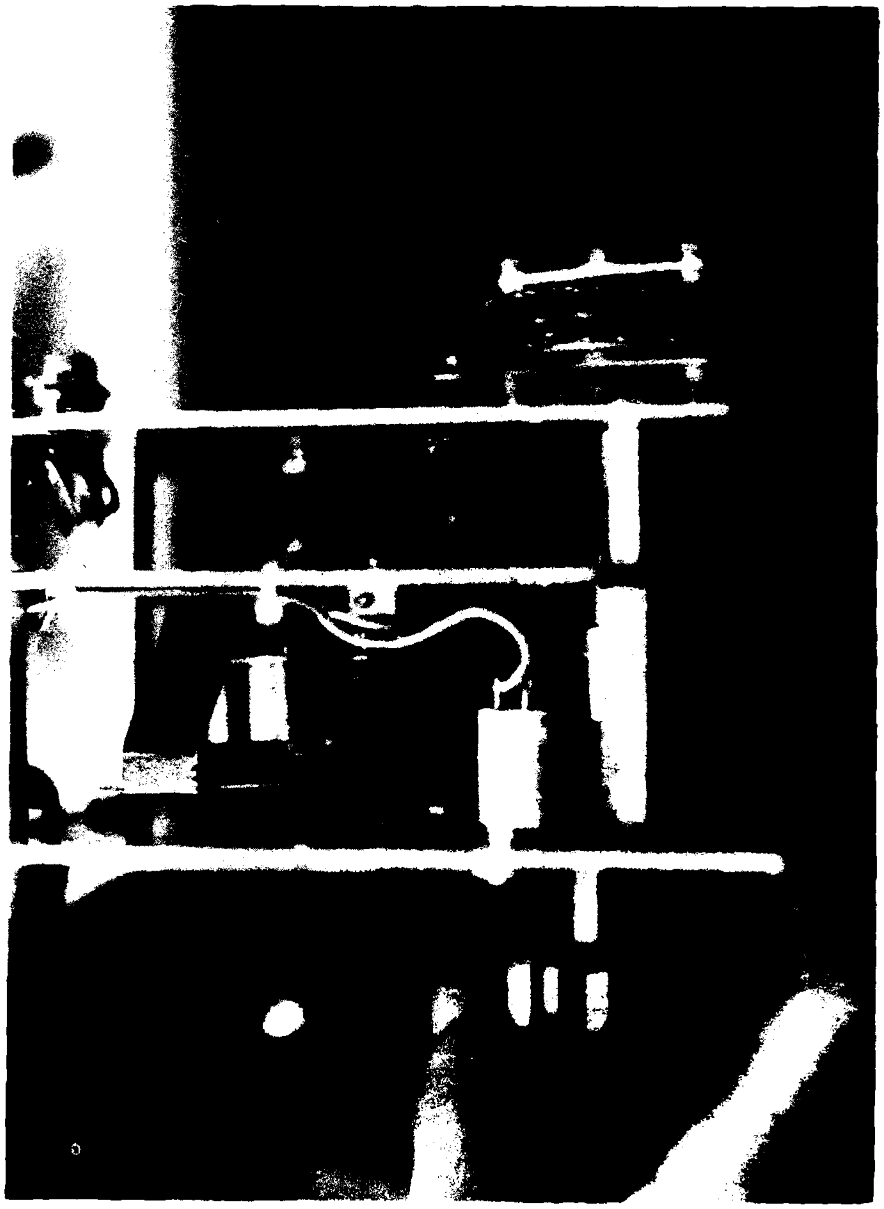

Figure 2. Facsimile Equipment, Showing Constructional Methods

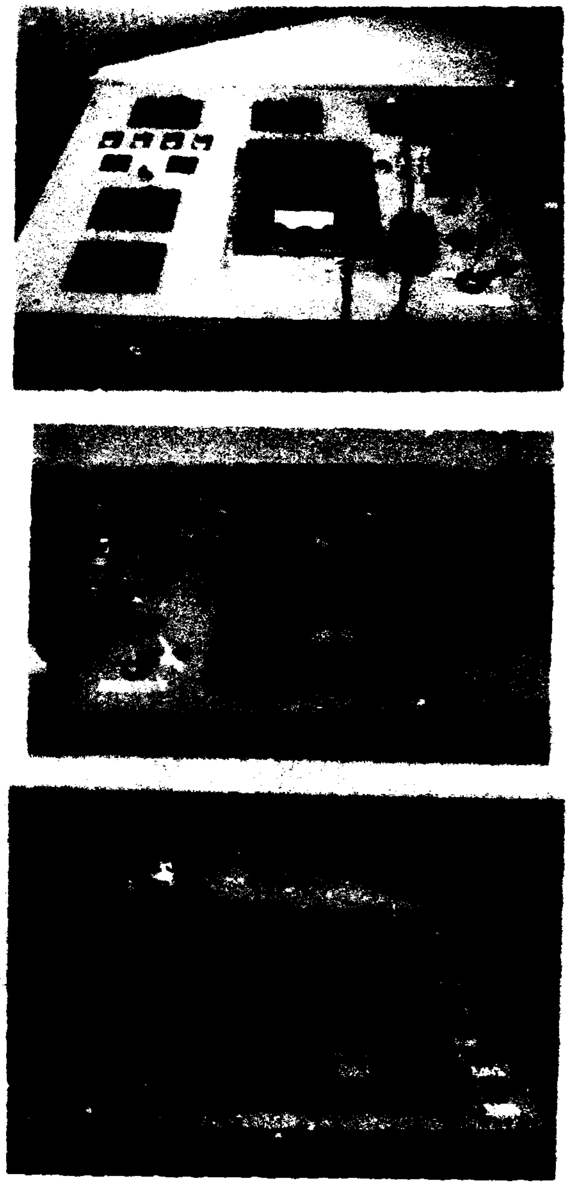

Figure 3. Ferry Simulator Console

ALTERNATE PAPERS

The following two papers were originally accepted for publication only.

OPTIMAL FIN ROLL STABILIZATION CONTROL SYSTEM DESIGN

by

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Abstract

The fin roll stabilization problem has history stretching back to about 1925 with the introduction of the hydraulically actuated fin. Classical controllers appeared in the mid to late 1950's both in the U.S and the U.K. Although the use of actuated fin remains the main technological principle of roll stabilization, few major advances in the design in the controller devices have occurred and the main technological change has been from analogue to digital devices.

This paper reports the design of an optimal feedback of state estimate as the principle of a potential new generation of fin roll stabilization system controllers. The technique enables adaptation to ship speed and sea state variations to be included. The objective was to produce a design procedure which would enable energy costs to be minimised and at the same time achieve good roll reduction. The procedure also enables excessive wear on the fin mechanism to be traded against the roll reduction improvements obtained.

Design time should be minimised and commissioning times reduced through the extensive use of computer aided design facilities. Portable IBM CAD tools have been developed to simply the design process. An advantage of the approach is that the trade off which must be made with classical design is avoided and the large number of filter and controller parameters is much reduced. It is possible to capture most of the design freedom in only two design variables which then give complete freedom to vary the speed of response of the system, to control robustness properties and weight the relative importance of roll reduction ratio against energy consumption.

The paper covers the following areas:

(a) The linear quadratic control and Kalman filter as required to create and test new designs.

(b) The structure and purpose of the software package

(c) Design guidelines and fault finding procedures for the linear quadratic and Kalman filter design technique.

The stochastic nature of the fin roll stabilization has long been known and possibly the first attempts to use appropriate optimal control techniques to exploit this knowledge were those of Chang (1961). However, these attempts had to await the work of Kalman to introduce recursive state-space forms and the subsequent development of CACSD packages like PROGRAM CC before the methodology was accessible to the engineer for easy use. This paper reports the development of a computer package to assist the engineer with the design of a Kalman filter and optimal control gain solution to the fin roll stabilization problem. The subsequent development of a new generation of adaptive roll stabilization control systems is an obvious potential of the work.

1. Model of the plant and its state-space representation

1.1 *Model of the plant*

The model of the fin/ship system, which is to be used in the design of the controller is given by the block diagram of Fig. 1.

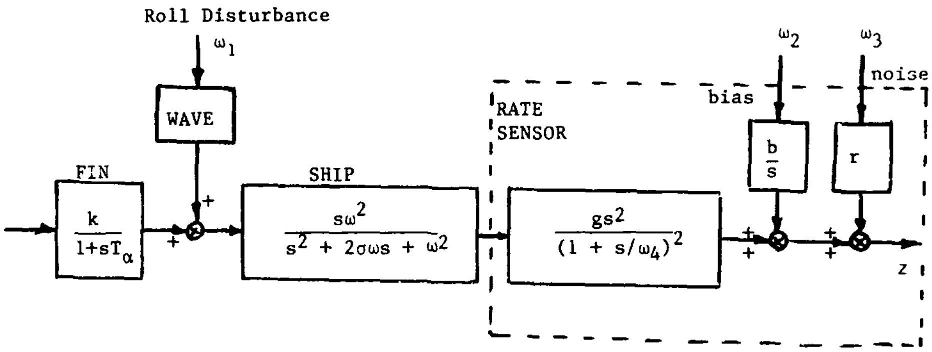

Fig 1 Block diagram of fin/ship model

It contains the blocks: fin actuator, wave, dynamics of ship and rate sensor. The corresponding PROGRAM CC macros for entering the values of the system parameters are **FIN**, **WAVE**, **SHIP** and **SENSOR**. The blocks are combined in the macro **MODEL** to form the complete model of the plant. The identification between sub-systems and macros is as follows:

System Component	Macro
Fin actuator	**FIN**
Wave disturbance	**WAVE**
Ship model	**SHIP**
Rate sensor model	**SENSOR**
Complete system	**MODEL**

The mathematical modelling begins from transfer functions which are converted to state matrix form and then combined to form the system model. The modelling approach is similar to, but simpler, than that given by Wong (1989a).

1.2 *Generic State Space Representation*

The model of the complete open loop system is given by the state space equations:

$\dot{x} = Ax + Bu + E\omega$ {States ~ dynamics}

$y = Cx$ {Output}

$z = y + v$ {Measured output}

where x is the n-vector of state variables, u = is the m-vector of control inputs, ω = is the ℓ-vector of noise inputs, y = is the r-vector of system outputs, v = is the r-vector of meassurement noise sources, and z = is the r-vector of measured system outputs.

The matrices of the system description are given as:

A is the (nxn) state-space matrix of the system,
B is the (nxm) control input matrix of the system,
C is the (rxn) output matrix of the system,
and E is the (nxℓ) distribution matrix for the process noise.

In the design package which uses PROGRAM CC, the state-space data (namely matrices A,B, E, and C) are stored and manipulated by a quadruple having the structure:

$$P_j = \begin{bmatrix} \overset{n\times n}{A} & \overset{n\times m}{B} & \overset{n\times \ell}{E} \\ \overset{r\times n}{C} & & \overset{r\times(n+\ell)}{0} \end{bmatrix}$$

It is therefore necessary to identify the basic structure and size of the indices n, m,r, ℓ.

1.3 *Complete State Space Model*

Using the block diagram of Fig. 1, working from left to right, the following structure obtains:

(a) *Fin actuator*
Contributes : one control input, α_c
one dynamic state

(b) *Wave model*
Contributes : one process noise input, ω_1,

(c) *Ship model*
Contributes : two dynamic states

(d) *Rate sensor and bias*
Contributes : three dynamic states (two for sensor, one for bias)
one process noise input, ω_2
one process output, y, roll rate with bias

(e) *Measurement*
Contributes : one measured output, z, measured y.
one measurement noise v.

The details are as follows:

State:

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} = \begin{bmatrix} \left.\begin{matrix}\text{filtered roll angle} \\ \text{filtered roll rate}\end{matrix}\right\} \sim \left\{\begin{matrix}\text{sensor} \\ \text{device states}\end{matrix}\right. \\ \left.\begin{matrix}\text{roll angle} \\ \text{roll rate}\end{matrix}\right\} \sim \left\{\begin{matrix}\text{ship model} \\ \text{states}\end{matrix}\right. \\ \text{fin angle state} \qquad \text{fin actuator} \\ \text{sensor bias state} \qquad \text{bias} \end{bmatrix}$$

Control Input

$u = (u_1 = \text{fin angle}, \alpha_c)$

Process noise input

$$\omega = \begin{bmatrix} \omega_1 \\ \omega_2 \end{bmatrix} = \begin{bmatrix} \text{noise input for wave disturbance} \\ \text{noise input for sensor bias} \end{bmatrix}$$

Noise sources ω_1 and ω_2 are zero mean, unit variance Gaussian white noise.

System output

$y = (y_1) =$ (roll rate sensor output with bias)

Measured system output

$z = (z_1) = (y_1$ plus measurement noise)

Measurement noise

$v = (v) =$ (measurement noise for output y_1)

Noise source v is zero mean Gaussian white noise of covariance $R = r^2$. In the block diagram of Fig. 1, the measurement noise $v = r\omega_3$ where ω_3 is zero mean, unit variance Gaussian white noise. PROGRAM CC uses the measurement noise covariance matrix as PN, where for this case:

$$PN = R = r^2$$

and r = r.m.s. amplitude of measurement noise.

2. Measures of Performance

The main measures of performance of the fin roll stabilization closed-loop system are given by the following expressions:

(i) *Stability and robustness*
Gain and phase margins

(ii) *Roll reduction*
(a) root-mean-square roll angle reduction
(b) reduction of peak roll angle in time-domain
(c) roll amplification with frequency

(iii) *Fin activity*
(a) root-mean-square fin angle
(b) peak value of fin angle in time-domain
(c) peak value of fin rate in time-domain

(iv) *Effects of sensor noise and bias on fin angle*
(a) root-mean-square fin angle due to sensor noise
(b) root-mean-square in angle due to sensor bias
(c) maximum fin angle due to sensor noise
(d) maximum fin angle due to sensor bias

(v) *Effects of sensor noise and bias on roll angle*
  (a) root-mean square roll angle due to sensor noise
  (b) root-mean-square roll angle due to sensor bias
  (c) maximum roll angle due to sensor noise
  (d) maximum roll angle due to sensor bias

2.1 *Stability and robustness*

The roll stabilizer system in closed-loop control has to be stable under nominal operational conditions. Furthermore, it should have some robustness to the modelling error of the design and any change in the behaviour of the controller as well as the system for the entire range of operational conditions. This reserved capacity is given by the stability margins which are the gain and phase margins in the Nyquist plot of the loop gain.

2.2 *Roll reduction*

Since the primary function of the stabilization system is to reduce the roll angle of the ship by closed-loop control, performance in this respect is very important. Roll reduction performance is measured in several ways. Firstly, there is the measurement of disturbance energy of roll in the controlled system. This is expressed in r.m.s. roll reduction which is the ratio of r.m.s. roll angle of the closed-loop system to that of the open-loop system. In time domain, the characteristic of interest is the ratio of peak roll angles of the closed-loop system to that of the open-loop system. This may be a good indicator of the performance. However, this should not be taken as a quantitative measure since the disturbance input is stochastic in nature and the peak value it gives depends on the amplitude and phase characteristics of the system. In the frequency domain, the frequency characteristics of roll reduction is an important measure of performance. This is because while roll reduction is often good at the natural frequency of roll, above and below this frequency there are peaks of roll amplification. It is important that the magnitude of these peaks of amplification should be small. If not, the closed-loop system will exhibit net amplification of roll when a change in the peak frequency of the disturbance coincides with either of these amplification peaks.

2.3 *Fin activity*

While the roll stabilizer system makes use of the fin to reduce roll it is important to minimize fin activity. This is because fin activity generates drag to forward motion thus causing increased fuel consumption. Furthermore, it causes hydrodynamic vibration in the water which is often undesirable in naval vessels. The most common measure of fin activity is the r.m.s. fin angle for a specified operational condition. When the angle of excursion and rate of excursion are limited, the maximum fin angle and maximum fin rate in the time domain are important measures of performance.

2.4 *Effect of sensor bias and noise*

When the control loop of the stabilizer system is closed, the bias and measurement noise of the sensor will affect the fin activity and the roll angle. In fact, these effects will be superimposed on that caused by wave disturbance. Thus sensor noise and bias will cause extra roll displacement and fin activity. Its presence in high amplitude will cause fin saturation and endangers the floatational stability of the ship. These effects of sensor noise and bias are measured in r.m.s. fin or roll angle caused by noise or bias in the frequency domain and maximum fin or roll angle caused by noise or bias in the time domain.

3.0 General structure of the controller

The controller takes the measurement of the physical variables of the ship and then, after some digital processing of the signal, produces the fin angle command signal as its output. The controller is a two stage operation:

(i) *Kalman filter*:
The signals measured are used as input to the Kalman filter. The Kalman filter gives the optimal estimation the states of the system which are not directly measured.

(ii) *The feedback controller*:
The feedback signal is then formed as a weighted sum of the estimates of the states. The weighting is the feedback gain of the controller. This can be chosen manually as in the Proportional-Integral (P.I) controller. Or, can be found, using the design macros, for a controller which is optimal according to the Linear-Quadratic cost function.

The block diagram of the controller using full-state Kalman filtering is given in Fig.2.

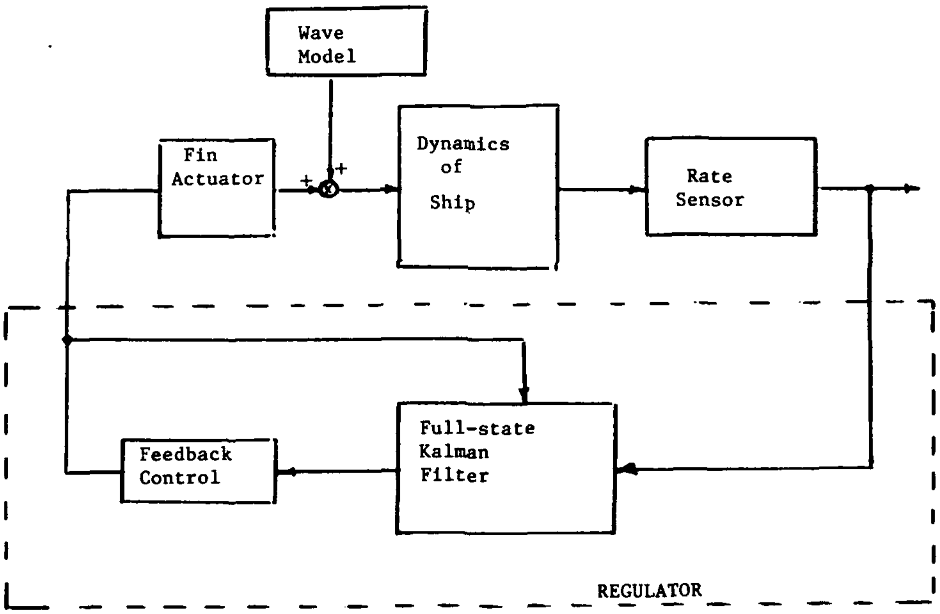

Fig 2 Controller with full state Kalman filter

It can be seen that the controller with a full-state Kalman filter has one input and one output because the feedback path of the fin command signal is internal to the controller software.

4. Kalman filter design

4.1 *The continuous-time Kalman filter*

The function of the Kalman filter is to give the best estimation of all the states in presence of measurement noise, bias and the bandwidth limitation of the sensor. The estimation is optimal with regard to the minimization of the cost function:

$$J = E\{(x(t)-\hat{x}(t))^T(x(t)-\hat{x}(t))\}$$

where E { . } is the mathematical expectation for random variables.

The equation of the Kalman filter is:

$$\dot{\hat{x}} = A\hat{x} + Bu + K_f(z-C\hat{x})$$

where

$\hat{x}$ is the Kalman filter estimate of the state-variable vector, x
u is the fin angle command input,
z is the measured output,
and K_f is the Kalman filter gain, which in this case is a vector.

The structure of the Kalman filter and the system in state-space form is given in Fig. 3. It can be seen that the structure of the Kalman filter mirrors that of the system.

4.2 *Discrete-time Kalman filter*

To be able to apply the discrete-time Kalman filter design, a zero-order-hold equivalent of the system model is adopted. To compensate for the time taken to generate the control signal the predictive form of the Kalman filter is chosen. That is the Kalman filter will predict the values of the state-variables at the beginning of the next sampling period. The control signal, which is the weighted sum of the predicted states, will then be updated just at the right instant without suffering any time delay. The equations representing this discrete predictive Kalman filter are given by the following difference equation:

$$\hat{x}_{k+1\,|\,k} = Ax_{k\,|\,k-1} + Bu_k + K_{pf}(z_k - y_{k\,|\,k-1})$$

where

K_{pf} is the gain of the predictive Kalman filter

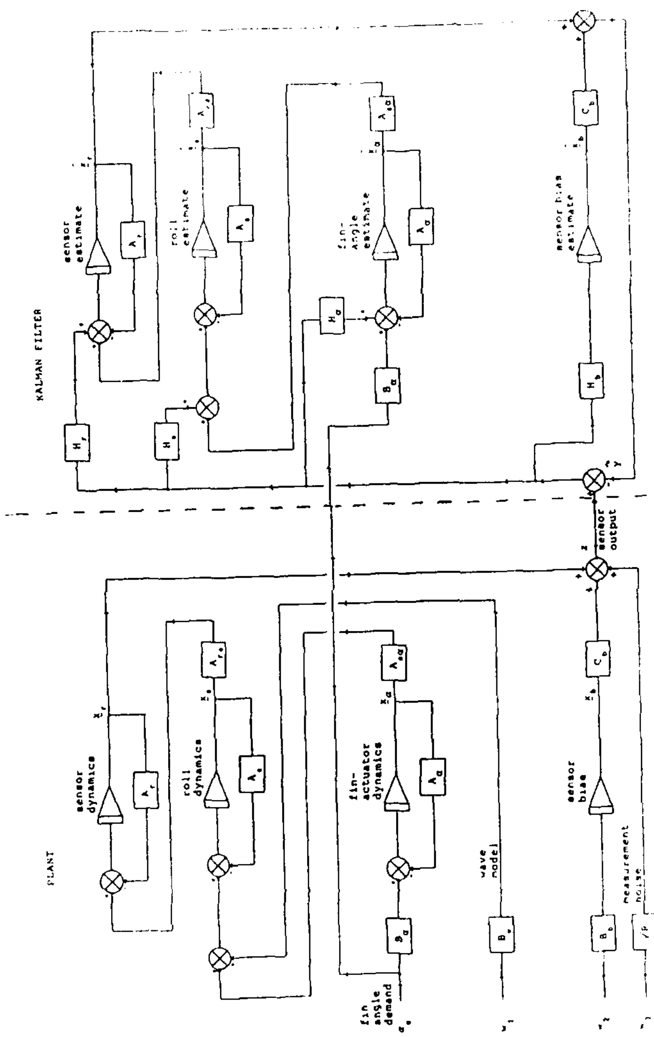

Fig 3 Block diagram of plant and continuous-time Kalman filter

$\hat{x}_{k|k-1}$ is the estimate of the state x at time k based on the measurement up to and including time k-1.

The equations show that, at time k, the Kalman filter is driven by the control effort u_k and measurement z_k, both taken at time k and by the predicted state-variables $x_{k|k-1}$ based on the measurement taken one sample earlier. For the closed-loop system the feedback control signal is:

$$u_k = K_c \hat{x}_{k|k-1}$$

where

K_c is the feedback gain.

Thus the feedback signal comprises a weighted sum of predicted state-variables.

5. Linear Quadratic Controller

The linear quadratic controller is optimal according to a cost function which is an integral of the weighted sum of squares of state-variables and control effort.

The six states are:

filtered roll angle, filtered roll rate, roll angle, roll rate, fin angle and sensor bias

The one control input is the fin angle command, α_c.

The cost function used in LQR design is:

$$J = \int_0^{\infty} (x^T Q_c x + \rho u^T R_c u)\, dt$$

where Q_c is the weighting on the state x, R_c is the weighting on the control effort u and ρ is a control weight multiplier. Matrix Q_c has to be non-negative definite, viz., $x^T Q_c x \geq 0$ for all real non-trivial x and matrix R_c has to be positive definite viz., $u^T R_c u > 0$ for all real non-trivial u.

To simplify the design task only the variables of primary importance can have non-zero weighting coefficients in the design program. These are:

roll angle, roll rate, fin angle, and fin angle command (φ, p, α and α_c)

The weighting matrix on state-variables is:

$$Q_c = \text{diagonal matrix } [0,\ 0,\ q_\varphi,\ q_p,\ q_\alpha,\ 0].$$

The weighting matrix on the control effort is:

$R_c = [r_{\alpha_c}]$

The weighting on the control effort can be modified by changing the multiplier ρ from its nominal value of 1, and this will modify the characteristics of the resultant closed loop system.

Many CACSD packages now have advanced features and routines to permit robust design. PROGRAM CC is no exception and the design macro LQR has another parameter which can be used for increasing the robustness of the closed loop system. Robustness of the design is achieved by increasing the stability margin. This involves the locating of closed-loop poles away from the boundary of stability.

When the robustness factor, RF, is set to 1, the stability margin of the standard design is kept. When the robustness factor is greater than 1, for continuous-time system, the closed-loop poles will be situated to the left of the vertical line $\sigma = 1 - RF$ in the complex frequency plane. A similiar provision is made for the discrete-time LQ-controller design macro DLQR. When the factor RF is greater than 1 the closed-loop poles will be situated within the circle defined by $|z| = 1/RF$.

The increase in stability margin is achieved at the expense of increased control effort. Moreover, the setting of robustness factor to value other than 1 will alter the effect of the tuning parameter ρ on the design. It is advisable to leave the step of robustness out initially and to incorporate it in later design iterations when found necessary. Further background on this type of design with prescribed degree of stabiity can be found in Grimble and Johnson (1988).

6. *Recommended route for the design of the digital controller*

The fin roll stabilizer is to be implemented as a sampled-data controller in a micro-computer. It is, however, recommend that the initial design should be performed in the continuous-time domain. When the resultant system is near to the target design then discrete-time controller design should begin. The stage of design in the discrete-time domain is a fine tuning of the design. This is because the closed-loop system which uses a continuous-time controller will usually perform better than that which uses an equivalent digital controller. Furthermore, the time required to complete a continuous-time design is only a fraction of that required for digital design. Another advantage is that the frequency-domain and time-domain characteristics of the continuous-time system are easier to interpret. Any anomaly in the design can be identified more easily and at an earlier stage of the design.

The design process using the computer package is outlined in the flow chart of Fig. 4.

6.1 *Tuning of the Kalman filter*

There are three stochastic inputs to the system and consequently there are three corresponding tuning parameters in the design of the Kalman filter. They are:

(1) pw = multiplier of wave disturbance input covariance
(2) pb = multiplier of sensor bias input covariance
(3) mu = multiplier of measurement noise covariances

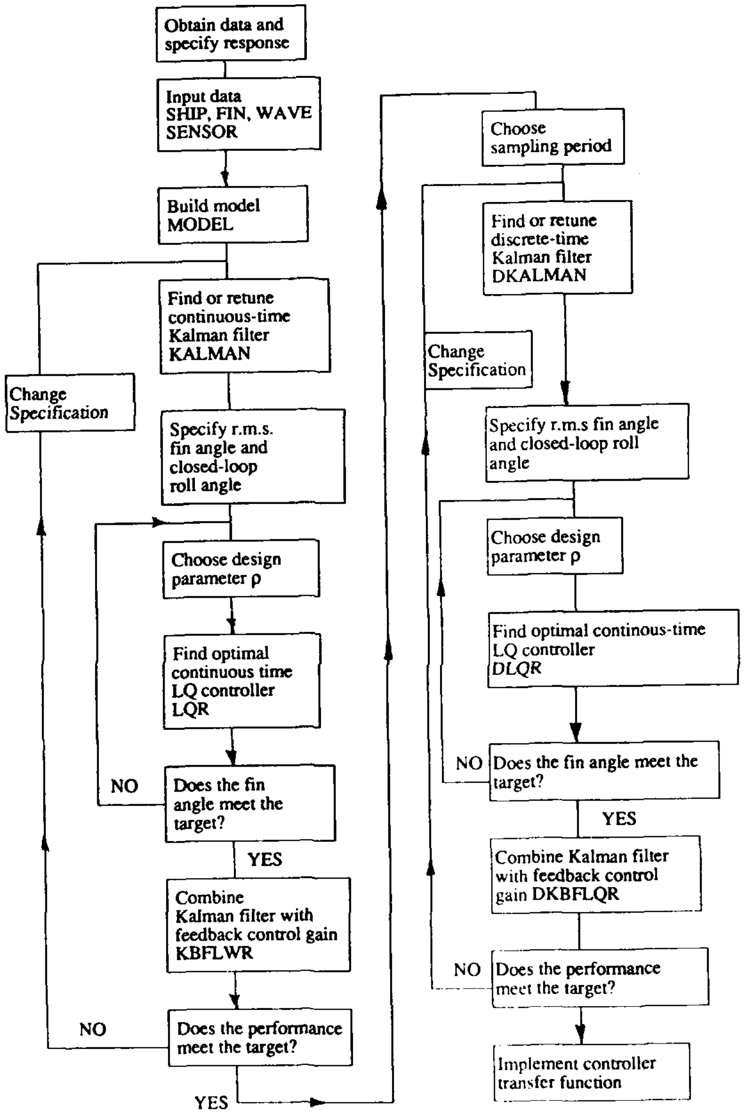

Fig 4 Design Flow Chart

If the noise statistics are precisely known or a nominal Kalman filter design is required, these multipliers should be equal to 1.

Further tuning may be required if the state estimation over a specific bandwidth needs to be more accurate. This, however, would result in a deterioration of accuracy for other frequencies. The tuning is accomplished by adjusting the relative values of the three multipliers.

Since sensor bias is modelled as the integration of white noise, its contribution to the sensor output is predominantly low frequency signal. The roll disturbance is modelled as white noise passing through a second-order transfer function which describes the roll dynamics of the ship. The effect of roll disturbance at the sensor output is a base band signal which rolls off at 40 dB per decade beyond the resonance frequency of roll. The measurement noise is white noise and will have the same amplitude for all frequencies.

It has been observed that, because of the presence of low-frequency bias, the Kalman filter will only give a good estimation of roll angle and roll rate around the resonance frequency of roll. Below a certain frequency the estimation decreases at 40dB per decade while the actual roll angle remains constant. By decreasing the multiplier of bias input covariance, pb, or increasing the multiplier of roll disturbance input covariance, pw, the bandwidth of good estimation around resonance increases. However the fin angle and roll angle of the closed-loop system would be influenced by the bias to an increasing extent.

With the mutipliers at their nominal values the roll angle and roll rate are over-estimated at frequencies above resonance. Increasing the value of the multiplier of measurement noise will reduce the over-estimation and lower the cut-off frequency of the Kalman filter. The other advantage is the reduction of the effect of measurement noise on the closed-loop system.

6.2 *Choice of weighting coefficients for the LQ controller design*

The weighting coefficients of the cost function have to be chosen so that the resultant closed-loop controlled system will meet the specification laid down. This may require some design iterations. From the system description, the r.m.s. roll angle of uncontrolled ship at the worst operational condition and the maximum fin angle are given. From the design specification, the mean square value of desired roll angle is known. If the objective of the design is to maximise roll reduction with the available fin activity, it may be appropriate to choose:

$$\text{Mean square value of fin angle command desired} = \frac{1}{2} \text{ (maximum fin angle allowed)}$$

Choice of weighting coefficents without knowing KBF response

By certainty equivalence principle, the optimal feedback gain of the system subjected to stochastic disturbance can be found as if the state-variables of the system are not perturbed by disturbance. That is the optimal gain is found as if the actual state-variables are used for feedback while in the actual system the estimated values from the Kalman filter are used. Thus the frequency characteristics of the filter is assumed to have no effect at this stage.

From section 5.0, the linear-quadratic-regulator (LQR) is optimal with regard to the following cost function:

$$J = \int_0^{\infty} (x^T Q_c x + \rho u^T R_c u) dt$$

where Q_c is the weighting on the state values, x and R_c is the weighting on the control, u.

Since the design object is to minimize roll angle, subject to the constraint on fin activity, the simplest and most logical initial choice is:

$q_{\varphi} = 1, q_p = 0, q_{\alpha} = 0$

$r_{\alpha c} = 1, \rho = 1.$

Using Bryson's rule,

$$\rho = \frac{\text{mean square value of roll angle desired}}{\text{mean square value of fin angle command desired}}$$

this will usually give a closed-loop system with:

$$\frac{\text{actual mean square value of roll angle}}{\text{actual mean square value of fin angle}} \simeq \rho$$

Although the resultant ratio is close to the desired ratio the actual mean square value of roll angle may not be equal to the desired value. The actual mean square value of fin angle may also be different from the desired value. Based on the ratio of mean square values of the actual fin or roll angle to the desired values of the corresponding angle, a new value of q_{φ} or ρ for the next iteration to approach the desired performance is suggested. By following the procedure given, a system with characteristics near to what is required can be achieved in a few iterations. However, the resultant performance is for a system which has assumed perfect measurement of all the states of the system without measurement noise or sensor bias. When noise and bias are included and the states are estimated with a Kalman filter, the performance of the closed-loop system will be different from the system which assumes perfect knowledge of the states. It is quite likely that further modification of the cost function will be required in view of the actual performance. Even so one important design goal at this state is to get the fin activity of the closed-loop system to be near to its target value. This is quickly achieved because the value found at this stage of the design is often only slightly higher than the target value.

7. Speed Adaptation

As the speed of the ship increase from zero when it is stationary, the fin effectiveness also goes up from zero as the square of speed. The damping coefficient of the roll motion, too, increases linearly with speed from a non-zero value.

Since the increase in fin effectiveness is the result of the increase in force generated by the fins as the speed increases, the torque output required from the fin actuator to maintain the same fin angle also increases with speed. Thus the actuator output will saturate if a large fin deflection is requested when the speed of the ship is high. As a result, the maximum fin angle allowed has to decrease when the speed exceeds a preset value. In fact, for speed higher than the preset speed, the fin angle demand has to be reduced as the inverse square of speed.

Since Kalman filter is a model-based state estimator, the model internal to the filter should be close to the roll characteristics of the ship for it to work. As the roll characteristics of the ship changes with speed, the model used by the filter should follow as well, in the ideal case. However, speed-adaptation cannot be built into a fixed-gain controller. Fortunately, extra gain elements at the output of the controller can be added to the system to make its characteristics the same as the model used by the filter.

One control scheme which produces the fin angle demand reduction with speed and at the same time maintains approximate model matching between the Kalman filter and the plant is given in the following block diagram of Fig. 5.

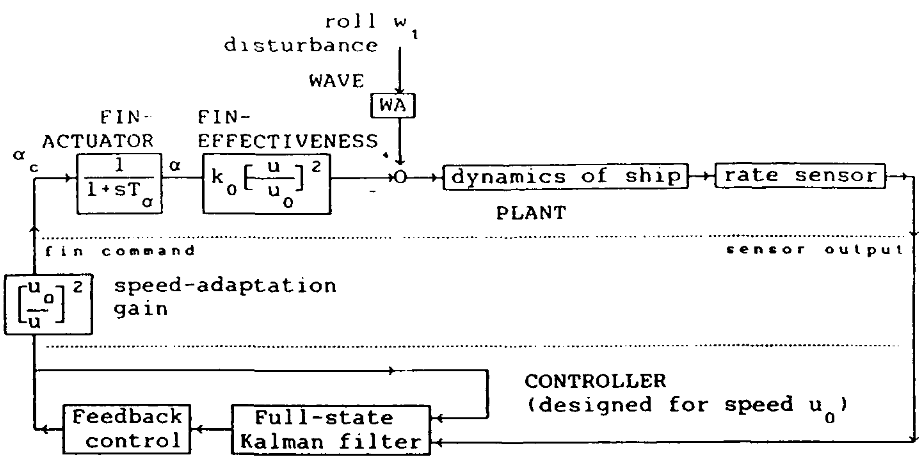

Fig. 5 Speed-adaptive Kalman filter + PI/LQR control

The match between the Kalman filter and the plant is only approximate in that change in damping coefficient of roll with speed is not reflected in the model used by the filter. However, some degree of model mismatch can usually be tolerated before the function of the filter deteriorates excessively.

If the fin deflection does not saturate, the stability property of the system would be maintained for all speed as the model used by the Kalman filter approximately matches the characteristics of the plant. However, the inverse-square relationship between fin angle demand and speed means that at low speed the fin demand for large roll disturbances can be so high that the fin system may saturate. This is the natural consequence of choosing to maintain constant roll reduction ratio when fin effectiveness decreases with speed. To avoid avoid instability caused by fin saturation, one way is to switch off the control system when fin activity is approaching saturation as a result of a combination of low speed and rough sea. A better way is to use a gain-scheduled controller which switches in an appropriate set of gain values according to condition or to make the system fully adaptive.

8. Conclusions

This paper reported the development of software tools based on the CACSD package PROGRAM CC for the design of optimal fin stabiization control systems. The studies took the following form:

Sequence of Steps

1. Build system model.
2. Find continuous-time Kalman filter gain.
3. Find continuous optimal feedback gain.
4. Form closed-loop KBG + LQR system and analyse characteristics.
5. Find discrete-time Kalman filter gain using same values of tuning parameters as continuous-time system.
6. Find discrete-time optimal feedback gain using same values of tuning parameters as continuous-time system.
7. Form closed-loop discrete-time KBF + LQR system and analyse characteristics.
8. Implementation of the controller.

The fin stabilization design package was used in several design exercises and for comparison with several related design studies including :

(i) A comparison of the relative performance of PID and LQG control schemes (Wong,1989a).

(ii) A feasibility study of a fully adaptive fin stabilization control scheme (Katebi,1989).

(iii) The development of design rules for LQG fin stabilizer systems (Wong,1989b).

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SHIPBOARD WORK METHODS BASED ON LIMITS OF MAN'S OPERATING CAPACITY: RELATED CONTROL SYSTEMS

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Marconsult S.p.A

1. ABSTRACT

This paper digests some results of experimental research regarding a work method aimed at the maximization of efficiency aboard merchant ships.

2. INTRODUCTION

In the late 60s and early 70s tankerships were being fitted with the first and most substantial automations (remote controls, vacstrips, etc.) and it was expected that a reduction of accidents due to human error would follow, as shipboard functions were being facilitated. Time proved that this was not the case. Accidents due to human error were then analized, experiments made and it was eventually proven that reduction of human error, like efficiency improvement, are attained by following the same pattern.

The research lasted about ten years and it was carried out in respect of the following scheme:

"Shipboard automation increases with the evolution of technology and it allows a reduction of number of crew on board. A level of automation exists above which an additional automation will cost more than the men it replaces. This level changes with the method of crew utilization, and a combination of the two can always be found which results into the lowest running + operating + capital cost, that is the best ship efficiency".

The studied methods of crew utilization were three:

- The traditional one, consisting of a crew division in three departments: deck, engine and catering.
- The one believed to be the method of the future, consisting of multipurpose operators.
- The one presented in this paper, consisting of operators trained in different functional areas, who run the ship as a team.

The experimental research proved that the result achieved by the third method are unmatched by the first and second, and so vast is the difference that the other two are unworthy of consideration regarding the future manning of merchant ships. The third method and its aspects worthy of consideration are reported in the following paragraphs.

3. THE METHOD

The quantity of know-how to run a ship was schematically established to be 100 of which 10 involved routines and 90 emergencies. As no average man could be expected to provide know-how 100, individual crew members were formed for specific tasks. It was assumed that each man could provide no more than know-how 30, of which 10 covered routine work and 20 a particular specialization. As know-how 90 was needed to cover the emergencies, 5 different specializations were formed (5x20=100). The know-how 100 was the sum of the separate know-how usually found in: deck staff, engine staff and shoreside technicians with competence in electronics, navigational equipment, etc. all taken together and assumed adequate to cope with "emergencies and critical operations" (ECO). When the know-how on board was still divided between deck and engine staff, 40%-50% of ECO was successfully controlled by the engine staff and 20%-30% by the deck staff. When 5 specializations were formed, 70%-80% of ECO was successfully controlled without distinction between deck and engine.

The experiments started with deck and engine officers, but trials with people coming from other schools (electronics and admiministration) showed even better results. Only training in team work was given: all other know-how was acquired by the individuals in the most economic ways, which proved adequate. Teaching/learning methods were shown to be quite irrelevant. These newly formed operators were covering regular watches and calling the specialized man in emergency or when in doubt. It was like running ships which had replaced the crew by shore technicians; everybody was busy and proud to be so. Yet those people were practically self made technicians. Salaries changed with seniority, matching the scale of comparable ships run by other methods.

4. HUMAN ERROR

The research on human error, which led to the experimental method described above, gave the results that follow. It was based on the analysis of 40 major and 200 minor accidents.

4.1 Wrong work methods

In roughly 80% of accidents where human error was determined to be the cause, the involved person had worked himself up to a situation he could no longer control.

It was typically the case of an operator complying with a work method that expected from him more than he could manage.

Consider automation, for example. Managers and maritime authorities believe that automation simplifies operations and therefore allows the operator to have more tasks than he can cope with: in fact automation reduces the work load, but does not simplify work. If a machinery consisted of 100 parts before being automated, it will consist of 1000 afterwards: the operator who satisfactorily ran the operation before, by knowing 60 out of 100, afterwards will not need to know 600 out of 1000 but, on the whole, more than the 60 he knew before. Managers and authorities distribute tasks as if only 20 should be known. This is quite common where multipurpose functions are pursued. Anything can be taught to a man, and he will pass his examinations, ONE AT A TIME. But there is a limit to what he can retain and, when the moment comes that he must recall many notions at one time, he will fail.

4.2 Automation complacency

In some 70% of accidents that initiated from automation fault, the person involved in human error admitted "not remembering EXACTLY how to go manual".

The passage from automation mode to manual control requires the knowledge of: a) all interfaces between machinery/engine and automation and b) how to run on "manual". Either one knows it or does not. The person who "thought that a particular function was on manual, when in fact it was still automated, or viceversa" was recurrent in the investigations. On ships there are many units of automation, which nowadays tend to be integrated for central control. This implies various degrees of automation. When red lights start blinking and a number of units must be excluded, there is usually no time to consult manuals and diagrams. If the operator knows EXACTLY what to do, he keeps the emergency under control; if he does not, chances are that he will worsen the situation.

When ships were automated, a motto was preached around the fleets studied in the research: "Never trust automation and always be prepared to go manual". Training, seminars and manuals were aimed at the effective observance of the motto's requirements, but results were mainly negative and a dangerous situation developed. Older staff knew how to go manual and let the younger care for automation. The younger ones, in their turn, trusted the older for going manual in case of emergency. The situation was dangerous because a) the older staff was not there to last for ever and b) in the split concern, between automated and manual tasks, the delicate interface did not receive enough attention by either parties. The persons without operational expertice, underestimate both the capabilities requested for going manual and the number of times it becomes necessary. They are fascinated by the reliability factors of the single units of automation and forget how many units a ship has. The ship where all are in working order for one month a year probably does not exist and yet most concern seems always to be addressed to the easy routine.

4.3 Poor communication

In 70% of the major accidents analysed, poor communication was recorded as a factor contributing to the accident.

In emergencies it becomes difficult to pass messages aboard one's ship, and it becomes even more difficult to pass them to others'. In some cases communication ended in confusion, when maximum coordination was required. Yet, where team work is practiced, one feels confident to keep emergencies under control thanks primarily to good communication. "Should masters and officers have improved their related skills?" It was pointed out that anything a master and an officer do, should be done better: communication, administration, shiphandling, navigation, meteorologic analysis, cargo handling, health care, etc. But the point was another: could a master and an officer do better, or was there a limit to their learning capacity? It should be appreciated that each one of the functions mentioned above is a profession in its own right. The superman capacity still fascinates many a manager but, for the salaries on offer, markets do not provide supermen.

4.4 Regulations

In roughlt 60% of the analysed accidents, the UNNECESSARY preoccupation to conform to the rule was recorded as a factor contributing to the accident.

Sophocles said: "One must learn by doing the thing; for though you think you know it, you have no certainty until you try". This principle is vastly disregarded. Person responsible for issuing regulations are too often unware of the difficulty involved in "doing the thing" because they are not familiar with it, therefore many rules do not take it into account. No operation can be run without rules, but too many and wrong ones result in diversion from their aim. In shipping, rules are too many, too important where trivialities are concerned and too strict where common sense and professionalism should come first. In the analysed accidents, cases were recorded of operators who: a) chose to follow common sense, and not the rule, with open disapproval of colleagues and subordinates. They found it difficult to act in this condition and eventually made mistakes unrelated to the disregarded rule. b) Conformed to rules which were too strict or limited to adequately cover the particular case and practically caused the accident by observing the rule. It will be appreciated that rules should either be written in huge volumes to cover all possible emergencies, or be guidelines only. Most shipping companies and, to a major extent, maritime authorities, issue rules which are neither. c) Could not think of the rule implications, and in fear of doing something wrong, they eventually went wrong. For many people, rules become sheer obsession. a) b) c) were headings of different studies, each one including precise accident descriptions.

4.5 Safety

In about 50% of the accidents, slow reflexes and, to a lesser degree, feebleness were recorded as factors contributing to the accident.

Standards of acceptable risk related to seamen's routines have changed considerably during the past 30 years. No modern safety rule would approve of a sailor setting sails on a sailing vessel, that involving too high a risk. Yet, ships have changed but the sea remains the same: during storms sophisticated ships continue to roll and pitch. Nowadays one sees men of 60 who still climb rope ladders better than men of 30, and officers who reach for the computer as boys reach for mum's hand. Computers are made to save work and time, not to generate laziness. The strapping seaman has been replaced by a push buttom man whose demotivation is growing with the sophistication of the gadgets he is being offered. Some ships in the U.K. still keep the victualling contract posted which states how much food a crewmember is entitled to: yet many a seaman also eats for the work that automation/computers do and are often overweight. These standards are not the best to cope with emergencies.

5. AUTOMATION IN THE EXPERIMENTED METHOD

The experimented method requires specialized operators and these are considerably different from the generic or multipurpose operators. The first aim at simplifying their task and don't like to get involved in more automation than is strictly necessary. They can provide for a good percent of their equipment maintenance/repair and the more complicated the equipment is, the higher their work-load becomes. The second must instead cope with a feeling of insecurity, which is growing with the complexity of the system they must control during routines and emergencies, therefore, they wellcome the expert systems that simplify their work. As they are primarily push button men, they don't care about maintainance/repair. Marconsult S.p.A has made in depth comparative studies on this matter. It was demonstrated how running + operating + capital costs decrease with specialised operators, to the point where one or two additions to the realistic minimum crew become economically justified. Crews of 8 to 14 men were considered in the studies. As this presentation does not allow for detail, one example is given to explain the concept.

In tankerships, automation provides for vacstrips. Vacstrips are used for the automatic drainage of cargo tanks on the assumption that drainage is a complicated operation which automation performs more efficiently than a multipurpose operator. However, safety rules require that a man is always present in the control room when tank drainage is in progress, irrespective of being performed by an automated system, therefore there is no saving in manpower.

Drainage is not a complicated operation for a competent pumpman and automation cannot beat him. Besides, it usually makes for a small portion of discharge time and can be excluded from watch duties. Why then have vacstrips?
It was proven how capital + maintenance + repair cost related to vacstrips can be saved entirely by operators capable of draining tanks.

The studies also brought to evidence that higly automated ships, ran by mere conductors, may perform well for a few years, but thence deteriorate, depreciate and cost more than ships run by specialized personnel. Two points, a.o., were highlighted in this connection: a) When turnround slows down, maintenance/repair in port tends to be rushed up and cost much more than the same maintenance/repair carried out at sea by specialized crew. b) Quite a few publicised "ships of the future" were and are being experimented, partly counting on government funds. Therefore, the true maintenance/repair costs are not easily traceable, and the traceable ones are sometimes adjusted to suit publicity.

6. RESULTS FROM THE EXPERIMENTED METHOD

The results from the experimented methods are resumed in the following points. Such methods can be easily accepted by seamen, not so easily however by shipping managers and maritime authorities, because they are in contrast to the prevailing trends, and several rules should be changed.

6.1 Human error

The percent of accidents due to human error was practically halved. The result was better, but the extent of the experiment would not allow to extrapolate to entire fleets.

6.2 Safety and efficiency

Safety and efficiency improved dramatically and, above all, it was proven that safety and efficiency are attained by following the same pattern.

6.3 Crew

Crew costs were purposedly kept at one level with those of comparable ships differently manned. Crew availability was not different from that of other ships: when an individual's functional area is restricted, the individual naturally considers his area's problems more in depth. Specialization derives from work methods. The same person who becomes a generic operator may become a specialized one.

6.4 Team work

The experimented team work was defined as follows: "A method to aggregate different competences in a way that persons, properly trained, stimulate each other and achieve results exponentially superior to those they would have achieved operating independently".

Japanese might have a natural propension for team work; but few other nationals have it. Team work must be taught: adaptation is not simple at the beginning, but afterwards eagerness to cooperate follows and results are excellent.

6.5 Choice of common sense

Team work does not call for more numerous or more expensive crews; it only calls for their different preparation. Why insist on teaching EVERYTHING TO EVERYBODY while the sum of the individual operators' know-how far exceeds the EVERYTHING provided by the multipurpose operator? Routine is not a problem where automation is in working order. During the experiments a boy of 12 was requested to prepare for loading an ULCC after assisting cargo control room operation for a couple of days: he did it all right. Emergency is the problem. This choice of specialized operators could be compared to that of a fitter who must choose ten hammers for his workshop: he can buy ten of equal or ten of different shapes and weights. It will be appreciated that ten of different shapes and weights will give him a better service.

6.6 Motivation

When seamen understand more about ship's equipment, they take pride in selfsufficiency generated by team work, and selfsufficiency transforms in considerable savings for the ship owners.

7 CONCLUSION

Technology improves but the percent of accidents due to human error does not decrease: at recent Commission of the European Communities Workshops it was shown the contrary for some sectors of industry. In the light of the experimented work method, this happens because the individual's capacity in controlling emergencies decreases with the growing complexity of his means, though it slightly improves by training when referred to past practice. Where the individual fails, the team succeeds. However, where team work is implemented, new work methods and new levels of automation are required in order to maximize efficiency. This conclusion derives from experiments and not from opinions.

SUPPLEMENT

SYMPOSIUM STATISTICS

The following four figures provide a brief analysis of the numbers of Technical Papers, national contributions, and topics covered in the Ninth and previous Symposia. As with all statistics, they are prone to many different interpretations! The analysis has been included to provide a basic indication of the trends in the area of ship control. It is based upon the information available at the time of printing. Also included are two Papers which were accepted for publication, but not for presention at the Ninth Symposium due to time constraints.

Many Papers could have been placed under more than one heading; indeed, the "Miscellaneous" category includes individual Papers covering a wide range of topics. Microprocessor and software related Technical Papers provide a large percentage of the total. This fact is not entirely evident from the statistics, as the subject headings represent in general the problems to be solved whereas microprocessors and software are in many cases a means of achieving these ends. Subjects becoming prominent in 1990 include damage control, survivability, simulation, and integrated monitoring and control.

TECHNOLOGY AREA	CANADA	CANADA/ITALY	FRANCE	GREECE	ITALY	ITALY/USA	JAPAN	NETHERLANDS	SWEDEN/USA	UNITED KINGDOM	UK/ITALY	UNITED STATES	USA/CANADA	USA/UK/SWEDEN	WEST GERMANY	TOTAL
AUTOMATIC MONITORING (SURVEILLANCE)	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
AUTOMATION & CONTROL	1	0	0	0	0	0	1	0	0	1	0	3	0	0	0	6
DAMAGE CONTROL	1	0	0	0	0	0	0	2	0	1	0	2	0	0	0	6
DIAGNOSTIC TECHNIQUES	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
DIGITAL DATA TRANSMISSION	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	4
DISTRIBUTED CONTROL	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
DYNAMIC POSITIONING	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2
ELECTRICAL POWER CONTROL	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
EXPERT SYSTEMS	0	0	0	1	0	0	2	1	0	2	1	0	0	0	0	7
HUMAN FACTORS	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	3
INTEGRATED CONTROL & SURVEILLANCE	1	0	0	0	0	0	0	0	0	4	0	1	0	0	0	6
MAN MACHINE INTERFACE	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
MANEUVERING	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	4
MANEUVERING SIMULATION	0	0	0	0	0	0	0	2	0	3	0	2	1	0	1	9
MICROPROCESSORS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
MISCELLANEOUS	2	0	0	0	0	0	1	0	0	1	0	1	0	0	0	5
OVERVIEW	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	4
PILOTING & NAVIGATION	0	0	0	0	1	0	1	2	0	2	0	1	0	0	0	7
PROPELLERS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
PROPULSION CONTROL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
PROPULSION CONTROL SIMULATION	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4
SOFTWARE	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	5
STABILIZATION	0	1	0	0	0	0	0	0	1	5	0	0	0	0	0	7
STEERING CONTROL	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
SYSTEMS ANALYSIS	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
TOTAL:	9	1	2	1	2	1	5	10	1	32	1	25	2	1	3	96

FIGURE 1: TECHNOLOGY CONTRIBUTIONS BY COUNTRY
- NINTH SHIP CONTROL SYSTEMS SYMPOSIUM 1990

TECHNOLOGY AREA	SYMPOSIUM YEAR									TOTAL
	66	69	72	75	78	81	84	87	90	
AUTOMATIC MONITORING (SURVEILLANCE)	0	3	8	4	8	7	3	0	3	36
AUTOMATION & CONTROL	6	2	8	0	0	7	0	0	6	29
BRIDGE	5	0	2	5	3	1	0	0	0	16
COLLISION AVOIDANCE	0	0	0	4	0	2	0	1	0	7
DAMAGE CONTROL	0	0	0	0	0	0	2	1	6	9
DIAGNOSTIC TECHNIQUES	0	0	0	0	0	0	2	0	1	3
DIGITAL DATA TRANSMISSION	0	0	0	0	0	0	3	3	4	10
DISTRIBUTED CONTROL	0	0	0	0	0	0	0	3	1	4
DYNAMIC POSITIONING	0	0	0	0	0	0	0	3	2	5
ELECTRICAL PROPULSION	0	0	0	0	0	0	0	2	0	2
ELECTRICAL POWER CONTROL	0	0	6	1	2	0	2	0	2	13
ENGINE HEALTH MONITORING	0	0	0	0	0	0	0	2	0	2
EXPERT SYSTEMS	0	0	0	0	0	0	0	3	7	10
HUMAN FACTORS	2	1	3	7	7	6	1	3	3	33
INTEGRATED CONTROL & SURVEILLANCE	0	0	0	0	0	0	0	4	6	10
MAN MACHINE INTERFACE	0	0	0	0	0	0	3	3	2	8
MANEUVERING	2	4	4	9	3	1	2	2	4	31
MANEUVERING SIMULATION	5	6	2	8	3	1	0	0	9	34
MICROPROCESSORS	0	0	0	0	7	4	2	0	1	14
MISCELLANEOUS	0	0	0	0	0	0	7	8	5	20
OVERVIEW	3	2	0	1	4	4	4	4	4	26
PILOTING & NAVIGATION	3	4	6	0	3	5	2	3	7	33
PROPELLERS	1	3	5	3	0	2	0	0	1	15
PROPULSION CONTROL	3	4	11	12	13	6	3	1	2	55
PROPULSION CONTROL & SURVEILLANCE	0	0	0	0	0	0	4	4	0	8
PROPULSION CONTROL SIMULATION	3	4	3	5	7	1	2	0	4	29
PROPULSION PLANTS/SIMULATION	0	2	4	0	2	3	1	2	0	14
SOFTWARE	0	0	0	0	0	0	4	5	5	14
SPECIAL CRAFT	8	9	3	6	7	3	4	4	0	44
STABILIZATION	3	5	6	3	0	5	2	0	7	31
STEERING CONTROL	0	0	0	6	11	12	7	8	2	46
SYSTEMS ANALYSIS	0	0	6	6	0	0	0	0	2	14
TOTAL:	44	49	77	80	80	70	60	69	96	625

FIGURE 2: TECHNOLOGY CONTRIBUTIONS BY SYMPOSIUM YEAR

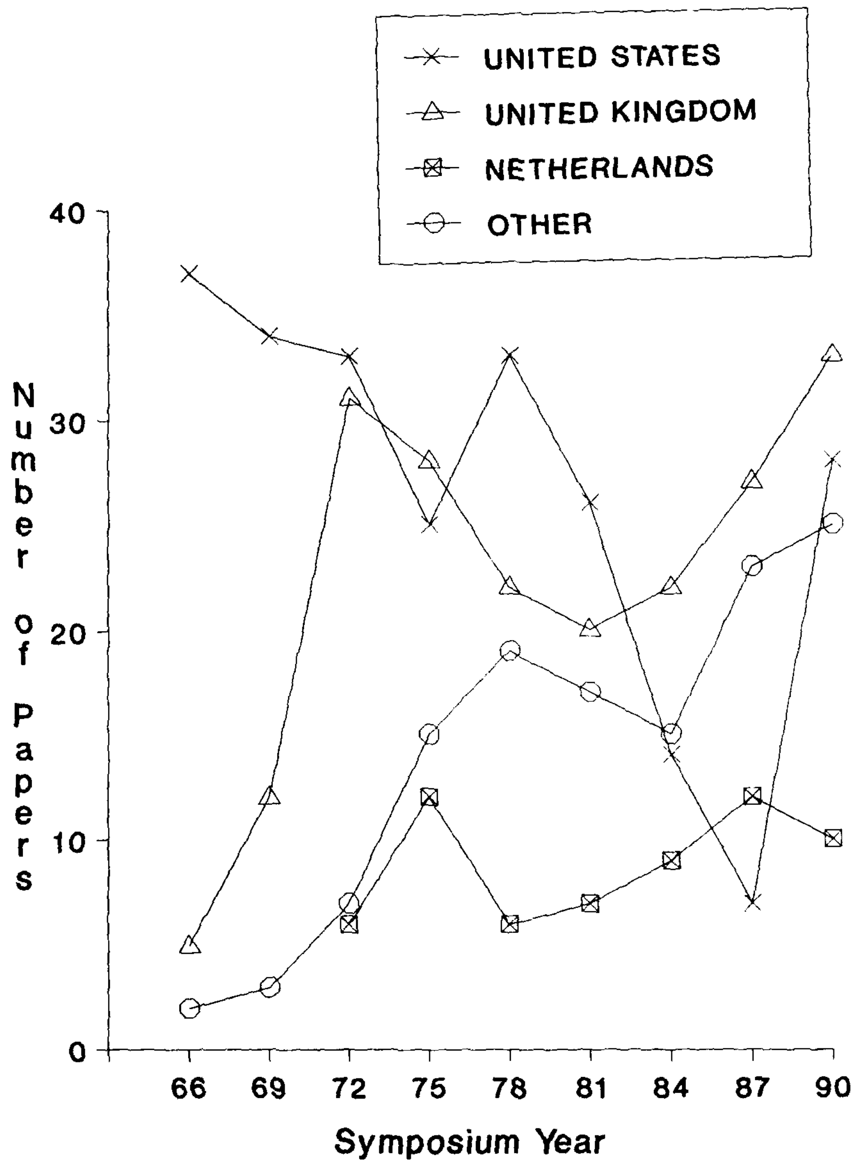


FIGURE 3. CONTRIBUTORS TO THE SHIP CONTROL SYSTEMS SYMPOSIA
(SEE ALSO FIGURE 4)

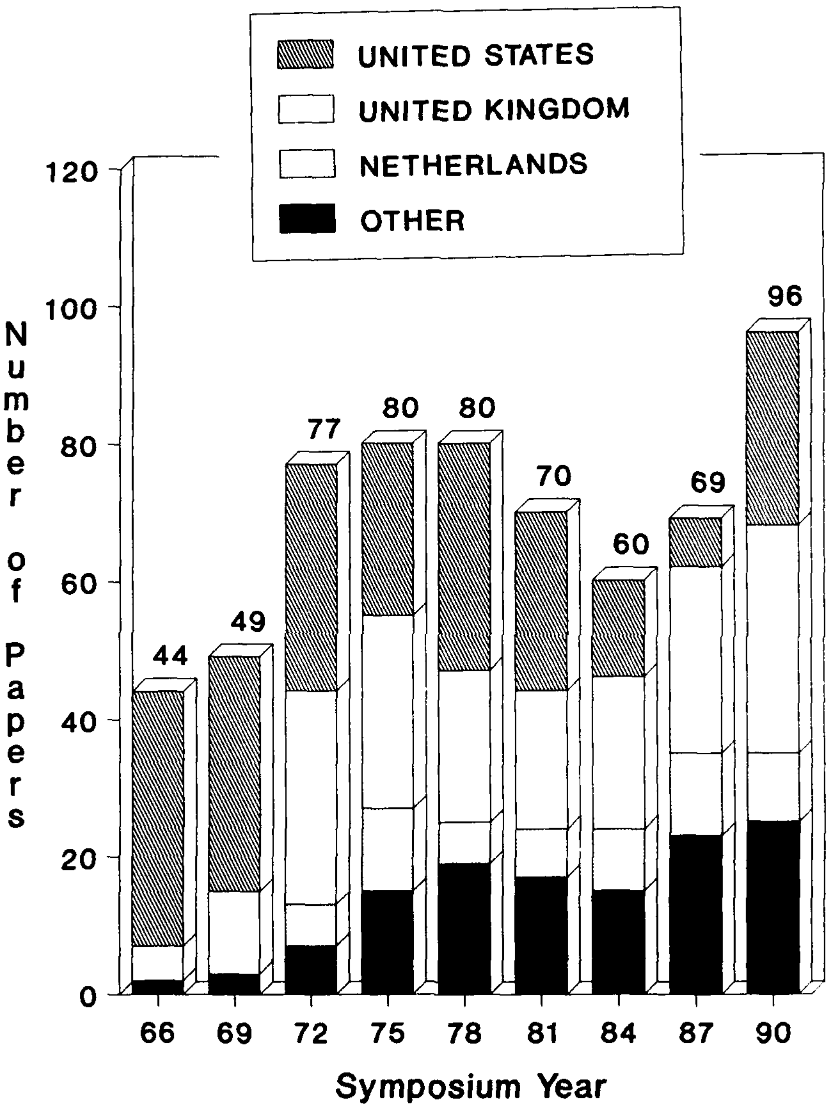
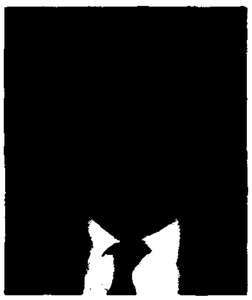


FIGURE 4. CONTRIBUTORS TO THE SHIP CONTROL SYSTEMS SYMPOSIA

SYMPOSIUM ORGANIZATION AND INTERNATIONAL COORDINATORS

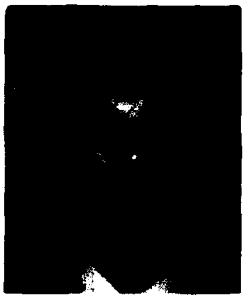
J. Moschopoulos BSEE MSEE
John Moschopoulos is Director of the Control Engineering and Instrumentation Division at Naval Sea Systems Command (NAVSEA) Washington, D.C. He also serves as the U.S. Project Officer for an International Exchange Program on Ship Control Systems as well as the Chairman of the Ninth International Ship Control Systems Symposium. Previous positions in NAVSEA were in the area of Machinery Instrumentation and Monitoring as Project Manager and eventually Branch Head. He received his B.S.E.E. in 1972 and M.S.E.E. in 1973, specializing in digital electronics, from the University of Texas. Before joining NAVSEA he spent several years working for commercial firms, initially as hardware digital design engineer and later in managerial positions, on computer systems integration for HVAC Controls and others.



S.K. Gupta BSC BTech(Hons) MS
Sudarshan K. Gupta, a general engineer at NAVSEA, Washington, D.C., obtained a Bachelor's degree in Mathematics, an Honors degree in Naval Architecture from I.I.T., India, and a Master's degree in Management Science from Johns Hopkins University. From 1969 to 1989 he worked at the Sparrows Point Shipyard of Bethlehem Steel Corporation, where, as the Naval Architecture Section Chief he managed the design, documentation and yard coordination for T-AK(X) Maritime Prepositioning Ships, TAGS 39/40 Oceanographic Survey Vessels and their propulsion control system, tankers, barges and other commercial vessels. Prior to this he worked in India, Sudan, England, Denmark and Canada. Mr. Gupta is a member of the Society of Naval Architects and Marine Engineers and Assistant General Chairman of the Ninth Ship Control Systems Symposium.

A.J. Mazzeo BE MA
Andrew J. Mazzeo attended the State University of New York Maritime College and graduated with a Bachelor of Engineering in 1974. He concurrently received a Third assistant Engineer's License in steam and diesels. In 1982 Mr. Mazzeo completed a Master of Arts in Business and Personnel Management from Central Michigan University. He has spent his entire career working in the area of marine engineering and engineering control systems. Before coming to NAVSEA he worked for Gibbs & Cox, Advanced Technology, and Propulsion Dynamics. In 1984 Mr. Mazzeo came to NAVSEA and presently is the Branch Head for Hardware and Software in the Engineering Control Division. He is responsible for managing a strong and independent control systems engineering branch to respond to systems level directives, performance requirements and criteria through systems analysis and engineering design, and life cycle support. Mr. Mazzeo is serving as the Coordinating Chairman for the Ninth Ship Control Systems Symposium.

Master Chief Petty Officer F.X. Leland USN (Ret)
Frank Leland retired from the US Navy after twenty three years service. Mr. Leland's career included tours in conventional submarines homeported in New London, Key West, Pearl Harbor, and San Diego. His last sea duty assignment was as Chief of the Boat in USS Dolphin AGSS 555. Between sea duty tours he served as a Work Study Analyst and a Navy Recruiter. Prior to retiring from active duty in 1983, Mr. Leland was assigned as the Command Master Chief of the Naval Military Personnel Command in Washington, D.C. During 1983 and 1984 he was a project engineer with American Systems Engineering Corp. Mr. Leland joined the Naval Sea Systems Command in 1984. His initial assignment was to coordinate an electrical cable improvement program. From 1985 to 1988 he was assigned to the Fiber Optics Program Office and was responsible for plans and programs. In October 1988 he assumed his present position in the Control Engineering and Instrumentation Division. Mr. Leland is the Financial Chairman for the Ninth Ship Control Systems Symposium.



D.E. Strawser BSEE Tau Beta Pi
Donald Strawser started with the Navy in 1971 fresh out of college. Except the a brief period with private industry (1980-1985), he has been with the Navy ever since. Positions he has filled during that time, include Research and Development in submarine silencing, AFFF fire fighting electrical systems, and Life Cycle Manager in machinery instrumentation. Prior to and during his employment with Navy, he has been somewhat involved in residential construction and woodworking. Along the way, he has managed to design and build two of the three houses his family has resided in (including the current one). Donald is also serving as the Facilities Chairman for the Ninth Ship Control Systems Symposium.

G. Garduno BS MS DScEE
Dr. Garduno received his B.S. degree in Electrical Engineering from New Mexico State University, University Park, NM; the M.S. and D.Sc. in Electrical Engineering from The George Washington University, Washington, D.C. Since 1966, he has been with the David Taylor Research Center, Annapolis, MD (formerly David Taylor Naval Ship R&D Center). He is currently Head of the Machinery Systems Engineering Branch working on controls, modeling and simulation of shipboard machinery systems. Additionally he is serving as the Technical Papers Chairman for the Ninth Ship Control Systems Symposium.

D.J. Marshall CD BEng MSc PEng
Commander David Marshall graduated from the Royal Military College of Canada in 1976 with a BEng in Engineering and Management. Following an appointment as Senior Engineer in HMCS PROVIDER, he obtained an MSc through completion of the Advanced Marine Engineering Course at RNEC Manadon, UK. He subsequently served in the Directorate of Marine and Electrical Engineering, NDHQ, Ottawa as the Machinery Controls Project Officer and the Technical Authority for the SHINMACS Advanced Development Model. After attending Staff College in 1987 and upon promotion to his present rank, he returned to DMEE to serve as Section Head for Machinery Controls, Instrumentation, Interior Communication and Passive Navigation Systems. He has recently been appointed to Maritime Command Headquarters, Halifax as the Senior Staff Officer Material Audit and Configuration.

D.W. East Dip Tech(Eng) CEng FIEE RCNC
David East began his engineering experience in 1947 when he joined the Post Office Engineering Department located in Birmingham. After 2 years service with the Royal Corps of Signals he transferred to London as an Assistant Electrical Engineer working on VHF radio services. In 1962 he was promoted Executive Engineer and worked on SHF radio links including the Post Office Tower. He transferred to the RCNC as an Electrical Engineer in 1965, serving at Portsmouth Dockyard and ASWE on a variety of tasks including Seawolf and as the Ship Weapons System Engineer for the Type 22 Frigates. Subsequently, he transferred to Bath in 1973 and was promoted to Assistant Director working on the electrical design of Invincible Class and MCMVs and latterly Large Ships of the Running Fleet. David East was appointed to his present post of Assistant Director of Machinery Control and Surveillance in 1982, a task covering both analogue systems in service and the implementation of digital technology in new design for the Royal Navy. In this post, David East assumed the role of General Chairman of the Seventh Ship Control Systems Symposium, was the UK Co-ordinator for the 8th Symposium and is now the UK Co-ordinator for the 9th Symposium.

A.C. Pijcke MSc CEng FIMarE
Anton Charles Pijcke entered the Royal Netherlands Naval College at Den Helder (branch: Marine Engineering) in 1949 and received his commission in 1952. During seaduty he served mostly on board frigates and destroyers. He was a Senior Lecturer in Marine Engineering at the Royal Netherlands Naval College for several years and was also Head of the Department of Technical Studies. He left the Royal Netherlands Navy as a Commander and is now a member of the staff at the National Foundation for the Co-ordination of Maritime Research at Rotterdam. He obtained his M.Sc. degree at London University, is a Fellow of the Institute of Marine Engineers and is a Chartered Engineer.

HONORABLE GERALD A. CANN
Assistant Secretary of the Navy
for Research, Development and Acquisition

On 12 March 1990, the Honorable Gerald A. Cann was sworn in as the first Assistant Secretary of the Navy for Research, Development and Acquisition. He is responsible for all acquisition policy and procedure and all research, development, production, shipbuilding, and logistics support programs within the Department of the Navy.

Mr. Cann graduated from New York University in 1953 with a Bachelor of Science degree in Geology/Geophysics. He served two years in the US Army Signal Corps before joining the American Machine and Foundry Company where he served as TITAN I Test Manager and as Deputy Engineering Manager for the TITAN I Division.

In 1965, Mr. Cann joined TRW Systems, Inc. where he specialized in providing analyses and consulting services to the US Navy on anti-submarine (ASW) systems.

In 1970, Mr. Cann joined the Office of the Secretary of Defense as Staff Assistant for Ocean Surveillance and subsequently served as the Assistant Director for Ocean Control.

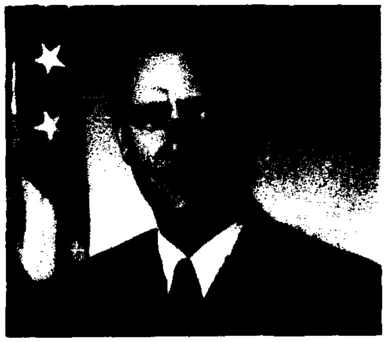
In 1977, Mr. Cann was assigned to the staff of the Secretary of the Navy as the Deputy Assistant for Systems. From 1979 through 1985, Mr. Cann served as the Principal Deputy Assistant Secretary of the Navy (Research, Engineering, and Systems) where he assisted the Assistant Secretary on all matters pertaining to Navy and Marine Corps research, development, test, and evaluation.

For the next two years, Mr. Cann established a private consulting firm and provided advice on long-range planning, allocations of independent research and development funds, congressional strategy, and teaming philosophy. His firm also specialized in the technical support for anti-submarine warfare, undersea, and air defense programs. Immediately preceding his appointment as the Assistant Secretary of the Navy, Mr. Cann served as the Vice President of the Undersea Warfare Center, General Dynamics Corporation.

Mr. Cann has been active in numerous committees sponsored by both government and industry, including the Defense Science Board, Naval Research Advisory Committee, National Academy of Sciences, Chief of Naval Operations Executive Panel, and the American Defense Preparedness Association.

During his career in both government and private sectors, Mr. Cann has been recognized through the award of the Defense Meritorious Service Medal, the Navy Distinguished Civilian Service Medal, and the National Security Industrial Association Charles Weakley Award, and most recently, the Navy Meritorious Public Service Award. In 1980, he was presented with the Distinguished Executive Award by the President of the United States.

Commander Naval Sea Systems Command
Vice Admiral Peter M. Hekman, Jr., USN



Vice Admiral Hekman, a 1958 graduate of the U.S. Naval Academy, was born in Ripon, California, November 30, 1933, and first joined the Navy as a member of the U.S. Naval Reserve in 1951. His initial sea tour upon being commissioned was aboard USS AGERHOLM (DD-826), after which he attended Engineer Officer School, then served in USS AMMEN (DD-527) and USS COGSWELL (DD-651). He returned to USS AGERHOLM as Engineer Officer in 1960, then served as Engineer Officer for construction and commissioning of USS HOEL (DDG-13).

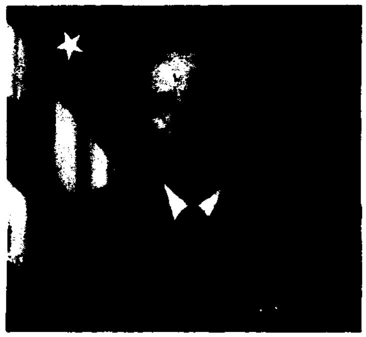
After completing Naval Nuclear Power training in 1964, he served as Material Officer at the AIW site, Nuclear Power Training Unit, Idaho Falls, Idaho. In 1966, he became Executive Officer of USS PRESTON (DD-795) and in 1968 assumed command of USS CHARLES BERRY (DE-1035).

Vice Admiral Hekman was awarded his Master of Science in Management degree in 1970 at the Naval Postgraduate School, Monterey, California. From 1971 through 1974, he served as Engineer Officer of USS ENTERPRISE (CVN-65). He commanded USS BENJAMIN STODDERT (DDG-22) in 1975 and 1976, participating in the final evacuation of American forces from Vietnam. He next served as Officer in Charge for construction of USS MISSISSIPPI (CGN-40), and in 1978 became USS MISSISSIPPI's first Commanding Officer. He returned ashore in 1980 as Senior Instructor, CNO Senior Officer Ship Material Readiness Course, located at the Nuclear Power Training Unit, Idaho Falls, Idaho.

Promoted to Rear Admiral in 1982, Admiral Hekman's flag rank assignments have included: Deputy Director for Operations, National Military Command Center, office of the Joint Chiefs of Staff; Commander, Cruiser-Destroyer Group ONE; Commander, Task Force SEVENTY-FIVE; Deputy Director, Office of Research, Development, Test and Evaluation, office of the Chief of Naval Operations; and Deputy Director for Surface Combatants, Naval Sea Systems Command. He assumed his present position as Commander, Naval Sea Systems Command on September 1, 1988.

Vice Admiral Hekman's personal awards include: Defense Superior Service Medal, Legion of Merit (with three gold stars), the Bronze Star Medal, the Navy Commendation Medal, the Navy Achievement Medal, the Armed Forces Expeditionary Medal, and various service and campaign ribbons.

Deputy Commander for Ship Design and Engineering, and
Chief Engineer, Naval Sea Systems Command
Rear Admiral Roger B. Horne, Jr., USN



Rear Admiral Roger B. Horne, Jr. was commissioned an ensign in the United States Navy in 1956 after graduating from the U.S. Naval Academy. He served aboard USS OZBOURN (DD 846) as Engineer Officer prior to departing for the U.S. Naval Postgraduate School in 1959. He was selected as an Engineering Officer at this time.

After departing from the Postgraduate School, he reported to Portsmouth Naval Shipyard to attend the Nuclear Submarine Construction School. Upon graduation, he was assigned to the Supervisor of Shipbuilding, Conversion and Repair at Ingalls Shipbuilding in Pascagoula, Mississippi, where he served as Submarine Project Officer for construction of nuclear submarines.

In 1968 Rear Admiral Horne was transferred to Puget Sound Naval Shipyard, where he was assigned initially as Nuclear Repair Officer and later assumed the duties of Nuclear Engineering Manager. He reported to Mare Island Naval Shipyard as Repair Officer in 1972. He served in that billet until reporting to the Engineering Duty Officer School as Officer in Charge in 1976. In 1977, he reported to Mare Island Naval Shipyard as Production Officer and assumed command of the Engineering Duty Officer School in 1980. In 1981 he took command of Puget Sound Naval Shipyard.

In 1984 Rear Admiral Horne reported to the Naval Sea Systems Command, Washington, D.C., where he served as Assistant Deputy Commander for Ship Design and Engineering, and then as Deputy Commander for Industrial and Facility Management. On 6 September 1988 he reported to his present position as the Deputy Commander for Ship Design and Engineering. In July 1990, he was also assigned duty as the Command Chief Engineer of the Naval Sea Systems Command.

Rear Admiral Horne is qualified in surface ships and as an Engineering Duty Officer in submarines. He is a member of the American Society of Naval Engineers, the American Bureau of Shipping, the Institute of Industrial Engineers, the Association of Scientists and Engineers of the Naval Sea Systems Command, and holds Master's degrees in both Mechanical Engineering and Business Administration.

CHAIRMEN'S BIOGRAPHIES

Captain(N) B. Baxter BASc MSc CD OMM **Ret.**
Thirty three years of service in the Canadian Navy include a wide range of employments and responsibilities in every aspect of marine engineering, including marine control systems. Positions included that of Project Manager for the Canadian nuclear submarine project, Director of Marine and Electrical Engineering, Deputy Project Manager for the Canadian Patrol Frigate project and a variety of shore and sea duties within the Canadian Navy marine engineering community. From 1980-1985 he was the director for marine control systems (DMEE 7) during which time he chaired the Seventh Ship Control Systems Symposium held in Ottawa Canada. Currently he is Project Manager for Litton Systems Canada on the $1.3B project to modernize the four DDH 280 destroyers.

Captain (E) R. Boerhorst RNLN
Captain Boerhorst was born in 1939 and joined the Royal Netherlands Navy as a midshipman in 1956. After completing his engineering training at the Royal Netherlands Naval College in Den Helder in 1959 he served as marine engineer officer in various surface ships until 1977 after which he joined the Ministry of Defence, Department of Mechanical Engineering. He served in his last seagoing job from 1981-1983 as marine engineer officer HNLMS Tromp. Joined the staff of the Admiral Netherlands Fleet from 1983-1985 and after that served again in the Ministry of Defence in various jobs as Department head. His present appointment is Director of Platform Systems.

Captain H. Brink MSc **RNLN**
Captain Hans Brink received his commission as an officer in the Royal Netherlands Navy (Marine Engineering) in 1960. After six years of service at sea, including two years in Netherlands New Guinea, and then three years at the Royal Netherlands Naval College, Captain Brink studied mechanical engineering at the Delft University of Technology, Delft, The Netherlands. He received the degree of M.Sc. in 1973. Subsequently, Captain Brink served as MEO on board a destroyer in the West Indies. In 1974, he became project officer for Ship Control Systems, Ministry of Defense, followed by assignment as head of the supervisor's team for the S-class frigates then under construction in Rotterdam. After serving at sea as MEO of a GM-frigate, and ashore as head of the Materiel Standardization Office of the Directorate-General, Materiel, Captain Brink was appointed head of New Construction Projects in the Naval Materiel Command. On November 1, 1986, he was appointed Attache for Defense Cooperation (Materiel) to the Royal Netherlands Embassy, Washington, D.C.

G.W. Cameron DipTech(Eng)
George Cameron is an executive director of Vosper Thornycroft Holdings and has held this position for the past seven years. In 1985 he was part of the successful management buy-out team which bought the company from British Shipbuilders. He is also Chairman of Vosper Thornycroft Industries Limited, A.V. Seawork Limited and Vice President of Chand Corporation, USA. He has spent over 20 years in Shipbuilding and Engineering since graduating in 1968 as an Electrical Engineer. He has held a number of professional, engineering and managerial positions including Deputy Chief Electrical Designer, Project Manager for the Ministry of Defence MCMV programme, General Manager of Support Services Division and General Manager of VT Controls Division.

A.E. Crout MSEE
After working as an Electrical Engineer with the Baltimore Gas and Electric Company, Mr. Crout entered the Marine Industry in 1968 at Maryland Shipbuilding and Drydock Company. In 1975 he left his position of Chief Electrical Engineer and entered Government Service as Chief Electrical Engineer in the Design Branch of Naval Engineering at U.S. Coast Guard Headquarters. In 1980 Mr. Crout entered the Senior Executive Service and accepted his present post as Deputy Director of Electrical Systems at the Naval Sea Systems Command. He is the Chairman of the Marine Transportation Committee of IEEE and Chairman of the Electrical Panel and Machinery Committee of SNAME.

A.M. Dorrian BSc(Hons)
A.M. Dorrian obtained an Honours BSc Degree in Mechanical Engineering from the University of Strathclyde, Glasgow in 1970. He then joined YARD Ltd, initially being employed in the Acoustics Group, and later in the Controls Group. Through various promotions, A.M. Dorrian was appointed Principal Consultant and Manager of the Controls and Simulation Group in 1980. He was appointed to the YARD Board in 1985 and became Managing Director of the company in April 1987. For your information, YARD is the premier European Systems and Engineering Consultancy Group, employing 850 people and with an annual turnover of over $50M.

D.W. East Dip Tech(Eng) CEng FIEE RCNC
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G. Garduno BS MS DScEE
Please refer to the Symposium Organization and International Coordinators Section

Professor Dr.-Ing. G. Grossmann

Professor G. Grossmann graduated in mechanical engineering from the University of Braunschweig in 1950 when he went to work in the R&D department of MaK. He gained his doctorate from the Technical University Hannover and joined the marine engineering department of Kieler Howaldtswerke and later moved to the R&D department. In 1969 he was appointed to the Chair of Marine Engineering at the Berlin University of Technology where his subjects include integrated marine engineering systems.

G. Hardwick

Guy Hardwick is Vice-President of Marketing and Quality Assurance at TANO Marine Systems. He has been with TANO for 20 years and in that time has worked on the control system designs for the U.S. Navy's LHA-1, LSD-41, TAO-187; the U.S. Coast Guard's WMEC-901, WHEC-715, and WAGB-10; and several commercial vessels. For the last ten years he has gained considerable experience in reliability, maintainability, human engineering, and shock-hardening design and testing. Hardwick received a B.S. degree in engineering science from the University of New Orleans. He published an article for the American Production and Inventory Control Society (APICS) and holds membership in NSPE, SNAME, ASNE, ISA, and APICS.

A.J. Healey BSc(Eng) PhD PE
Dr. Healey was graduated from London and Sheffield Universities with the degrees B.Sc.(Eng) and Ph.D. in Mechanical Engineering in 1961 and 1966 respectively. He emigrated to the US in 1966 and has taught at The Pennsylvania State University, MIT, The University of Texas at Austin, and the Naval Postgraduate School. He was promoted to Full Professor of Mechanical Engineering in 1974 at the University of Texas at Austin, and in 1981, he joined Brown and Root Inc. as manager of the Pipeline and SubSea Technology Research Group. In 1986, he assumed his present position as Professor and Chairman of Mechanical Engineering at the US Naval Postgraduate School. His areas of specialty include Mechanical System Dynamics, Vibration, and Control Systems, and he is presently the leader of an Interdisciplinary Project in Mission Planning, Navigation, and Control for Autonomous Underwater Vehicles at NPS.

Rear Admiral R.B. Horne, Jr, USN
Please refer to the Symposium Guest Speakers Section

Commodore R. James CEng FIMarE **RN**
Commodore James was born in 1940 and joined the Navy in 1959. As well as a wide range of appointments at sea and in engineer officers' training ashore he has held four posts, including the present, in the Procurement Executive of the Ministry of Defence. As Director General Marine Engineering he is currently responsible for the specification, development and through life technical support of all marine engineering equipments and systems. In addition to the development of all ship, as opposed to weapon, control and surveillance systems his responsibilities cover associated shore training and simulation packages.

E.T. Kinney
Mr. Kinney is the Executive Director of the Ship Design and Engineering Directorate, Naval Sea Systems Command. He is an honors graduate of Michigan State University, having received his BS degree in Civil Engineering in 1952. He has continued his education at George Washington University in the Engineering Administration graduate program, and is a graduate of the Federal Executive Institute. He began his engineering career in 1952 as engineer-in-training in the Hull Division of the Bureau of Ships. Subsequently, he served in a number of responsible technical and management positions in the Naval Sea Systems Command and the Naval Material Command. These assignments include Technical Director, Senior Project Coordinator and Program Management responsibilities in the Machinery Systems Division; CNM Program Management responsibilities in NAVMAT Headquarters; and Executive Director, Ship Systems Directorate, Naval Sea Systems Command. Mr. Kinney's professional and technical activities have been broad and varied. He is a life member of ASNE, TAU BETA PI and CHI EPSILON and holds membership in ASTM, SNAME, the Conference of Federal Environmental Engineers, and ASE. He served as a two term president of ASE and is currently Chairman of the ASTM Shipbuilding Standards, Machinery Subcommittee. He is also a member of the SNAME Ship Production Executive Committee. He has authored a number of technical articles and papers and chaired numerous technical symposia. He has been a frequent contributor to the Naval Engineers Journal. As part of his professional career, he has represented the Navy at several federal, national and international technical assignments. Mr. Kinney has been the recipient of the Chief of Naval Material Special Achievement Award, two Navy Superior Civilian Service Awards and the ASE Silver Medal Award.

Dr. T. Koyama *DEng*
Professor of ship design, Dept. of Naval Architecture and Ocean Engineering, University of Tokyo. BS(1962), MS(1964) and Dr. of Engineering(1967) all from University of Tokyo in the field of naval architecture. Meritorious member and Director of general affairs for the Soc. of Naval Architects of Japan. Also member of Soc. of Instrumentation and Control Engineering and others. Recent field of work is Computer Integrated Manufacturing for the ship building, Intelligent CAD system, marine traffic and ship control and related areas.

Commander G. Livingston BS NE MS PE **USN (Ret)** Mr. Livingston retired from the US Navy after twenty-two years service. Between 1957 and 1965, he served in a destroyer, a conventional and a nuclear submarine. In 1965, CDR Livingston entered the Engineering Duty Officer (EDO) Program. As a Submarine EDO, CDR Livingston served tours of duty at the Norfolk Naval Shipyard (Submarine Type Desk), the USS CANOPUS (SSBN Repair Ship, Repair Officer) and the Naval Sea Systems Command (Assistant Project Manager for Advanced Nuclear Attack Submarines). Retiring in 1979, Mr. Livingston joined ORI, Inc. where he technically managed ORI's TRIDENT Ship Control Support to NAVSEA and DTRC. Mr. Livingston is currently Vice President of ARC's (formerly ORI) Submarine Systems Group which supports: the OHIO Class and SSN21 Ship Control Programs at NAVSEA and DTRC; and the DTRC Ship Hydrodynamics Department and Ship Acoustics Department.

Commodore R.M. Lutje-Schipholt CEng FIMarE **RNLN** Graduate training was received at the Naval Academy Den Helder and The Technical University Delft in The Netherlands. Postgraduate engineering training was received during the advanced marine engineering course in Greenwich. One year at the Naval War College in The Netherlands completed in 1979 the naval education. Serving in cruisers, minesweepers, and frigates, lastly as Chief Engineer on The Netherlands flagships TROMP and THE RUYTER, was followed by posting at Naval Headquarters in The Hague. First as Director of Fleet Maintenance and since 1988 as Director of New Construction and Chief Naval Engineer Officer.

B.D. MacIsaac MEng PhD
Dr. MacIsaac graduated from the Technical University of Nova Scotia in 1970 with an Honours B.Eng. He subsequently completed his M.Eng. and Ph.D. at Carleton University specializing in gas turbine control systems. He joined the National Research Council in 1973 where he participated in a number of R&D projects in the area of propulsion system controls. In 1979 he formed GasTOPS Ltd., an engineering company which specializes in machinery simulation, control system design, and gas turbine health monitoring. Much of this work is with naval gas turbine systems. Dr. MacIsaac is author of many technical papers in his field and is a guest lecturer at Carleton University. He is active in a number of professional societies.

Commander M. Marks BSc(Eng) CEng FIMechE FIMarE **RN**
Commander Marks joined the Royal Navy in 1962, qualified as a marine engineer officer and served as the Flight Deck Engineer Officer of HMS ALBION. He completed a post graduate course in engineering design and was then appointed as the Deputy Engineer Officer of the frigate HMS JUNO. He had two appointments with the Ministry of Defence, Procurement Executive during the period 1975-83 where he worked on the development of marine steam plant, shafting systems and propellers. These appointments were separated by two years as the Senior Engineer of the carrier HMS BULWARK during a setting to work from reserve period. From 1983-85 he served as the Marine Engineer Officer of HMS FIFE, a destroyer with a combined steam and gas turbine plant before moving to the New Entry Training Establishment, HMS RALEIGH, as the Executive Officer. Early in 1988 he moved to Washington to take up his current appointment as the Marine Engineering Liaison Officer where he represents the Royal Navy and works closely with Naval Sea Systems Command on a wide range of mechanical and electrical engineering topics.

D.J. Marshall CD BEng MSc PEng
Please refer to the Symposium Organization and International Coordinators Section

Lieutenant Commander R.J. Martin BSME OE MSME **USN**
Lieutenant Commander Richard J. Martin enlisted in the U.S. Navy in 1971 and served as an electrician's mate on a nuclear submarine until 1975. In 1978 he graduated with Distinction from Purdue University with a Bachelor of Science Degree in Mechanical Engineering. He subsequently served on two nuclear submarines in various nuclear engineering billets and became an Engineering Duty Officer in 1982. LCDR Martin is a 1985 graduate of the Naval Construction and Engineering Program at the Massachusetts Institute of Technology where he received an Ocean Engineer Degree and a Master of Science Degree in Mechanical Engineering. While assigned to the Naval Sea Systems Command, he held assignments as the project engineer for the stern appendage design and control systems integration, and as Deputy Ship Design Manager for the SEAWOLF class submarine. He also served as project engineer for the first installation of an automatic control system on an operational 637 class submarine. LCDR Martin is currently assigned as a Program Manager in the Defense Advanced Research Projects Agency (DARPA) Submarine Technology Program. He is a member of PI TAU SIGMA, American Society of Naval Engineers, Naval Submarine League, and serves on the SNAME Ship Controllability Panel.

A.J. Mazzeo BE MA
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J. Moschopoulos BSEE MSEE
Please refer to the Symposium Organization and International Coordinators Section

Captain F. Patch BS MS **USN**
Captain Frank Patch received a BS in Physic from Boston College and an MS in Computer Systems Management from the Naval Postgraduate School. Afloat experience includes diesel submarines USS GREENFISH and USS WAHOO, and nuclear submarines USS FRANCIS SCOTT KEY and USS SHARK, where he served as Engineer Officer. Captain Patch served at Norfolk Naval Shipyard in submarine repair and then as Repair Officer aboard submarine tender USS SIMON LAKE. He served next as SSBN Project Officer in NAVSEA, and then as Director, Propulsion Systems Subgroup. After serving at Portsmouth Naval Shipyard from 1985 to 1989, he reported back to Washington in July 1989, where he is the Assistant Deputy Commander, Ship Design and Engineering Directorate, NAVSEA.

G.S. Penrose BSc(Eng) FIEE CEng RCNC
George Penrose has worked for the UK MOD all his life. He started as an electrical apprentice in 1947 and progressed via RNEC Manadon and RN College Greenwich to becoming an electrical engineer. He has served at sea as an electrical officer in HMS ALBION (Fleet Carrier). His career as a civilian has been in various posts in UK MOD in different parts of UK in connection with the specification and construction of both submarines and surface warships. His field of interest covers all electrical aspects (ex weapons) including machinery control. He has held the post of Director Electrical since 1984. He is married with two daughters, and his interests include golf and fell walking.

Dr. J. Raat
Jan Raat acquired his MS in Aeronautical Engineering at the Technological University of Delft, The Netherlands, in 1960 and his PhD at the University of Maryland, USA in 1966. He held various posts in research and research management in the USA, among others at the Institute for Fluid Dynamics and Applied Mathematics of the University of Maryland, the US Naval Surface Weapons Center at White Oak and the Convair Division of the General Dynamics Corp. in San Diego. In 1976 he was appointed Head of the National Programmes Coordination Office of the European Space Agency in Paris and in 1981 Director of the Netherlands Foundation for the Coordination of Maritime Research in Rotterdam.

Captain(N) D. Riis OMM CD BEng MSc PEng
Born in Ancaster, Ontario, Captain Riis joined the Canadian Forces in 1960 and attended Royal Roads Military College and the Royal Military College of Canada. He received his BEng in 1964. Following service as Engineering Officer in HMCS ANNAPOLIS from 1968 to 1970, he served for three years in the Naval Engineering Unit Atlantic. Post-graduate studies at the Royal Navy Engineering College Manadon, England led to an MSc in Marine Engineering in 1974 and three years in the Directorate of Marine and Electrical Engineering, NDHQ, Ottawa. In 1977, Captain Riis returned to Manadon for two and one half years as a lecturer and then attended the Royal Naval Staff College at Greenwich, England in 1980. Following a year as the Engineering Officer in HMCS ATHABASKAN, he was promoted to Commander and served for five years in the Ship Repair Unit Atlantic both as Planning Officer and Production Commander. He returned to NEU(A) in 1986 as the Naval Engineering Programmes Officer and in 1988 became Division Commander, Marine Systems Engineering Division at the Fleet School in Halifax. Following promotion in July of this year, Captain Riis assumed his current position as Director Marine and Electrical Engineering at National Defence Headquarters, Ottawa.

C.J. Rubis MS
Mr. Rubis is Chairman and CEO of PDI CORP. in Annapolis, Maryland. His career has been devoted to systems engineering including: electronics, and machinery control systems. He has an MS degree from the University of Illinois and has held teaching positions with Drexel University and the Naval Academy, Systems Engineer for Martin Marietta and Head, Control Systems Branch David Taylor Research Center. He has worked principally in the areas of ship machinery dynamics and control for the past 25 years and contributed to the literature with publications in various journals and symposia. In 1969 he was the technical Co-Chairman of the 2nd Ship Control Systems Symposium in Annapolis, Maryland.

Commodore M.T. Saker CD BEng PEng
Commodore Saker was born and raised in Toronto, Ontario. He graduated from the Royal Military College of Canada in 1964 with a BEng in Mechanical Engineering. After three years of general naval service, Cmdre Saker trained at the Royal Navy Engineering College, Manadon, England and later studied advanced marine engineering at the Royal Naval College, Greenwich, England. He has served in a number of ships including Canada's first military hydrofoil HMCS BRAS D'OR and the DDH 280 Class destroyers. Shore appointments have included engineering jobs in Maritime Command, Halifax and in National Defence Headquarters, Ottawa. Cmdre Saker is a graduate of the Canadian Forces Command and Staff College and the National Defence College. Cmdre Saker was appointed to the Canadian Patrol Frigate Project Office in August 1983, one month after signing of the prime contract for the design and construction of six frigates. Over the next four years, he served in two Deputy Project Manager positions before being promoted to commodore in 1987 and named the CPF Project Manager. In July 1990, Cmdre Saker assumed his current appointment as Director General Maritime Engineering and Maintenance at National Defence Headquarters, Ottawa.

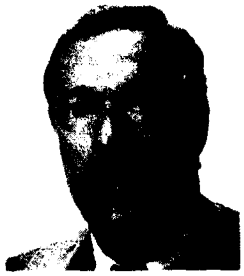
B. Taylor BSc
Barry Taylor attended the Royal Military College of Canada, graduating in 1968 with a BSc. After completing basic naval training, he obtained a Bridge Watchkeeping Certificate, with subsequent employment as Communications Officer. Upon completion of his Engineering Certificate of Competency, appointments encompassed the following: Engineering Officer in several HMC Ships; various engineering positions in HMC Dockyards; and Officer-In-Charge of the Engineering Division, Halifax. His last naval appointment in Defence Headquarters was as Section Head responsible for Machinery Controls, Interior Communications and Navigation Systems. He was also Project Manager for the Shipboard Integrated Machinery Control System (SHINMACS). In 1987, after a 24-year naval career, he moved to CAE Electronics Ltd. of Montreal, Canada where he is currently Manager, Marine Systems.

D.T. Van Liere BSMarE
"Van" Van Liere has over 35 years' experience in planning, executing, and managing marine engineering and shipbuilding activities. He served four years as the Deputy General Manager of Westinghouse Machinery Technology Division (MTD) before becoming General Manager in January 1988. Westinghouse MTD specializes in naval engineering for the U.S. Navy. Previously Mr. Van Liere was Manager of Manufacturing Planning and Director of Operations at Westinghouse Offshore Power Systems in Jacksonville, Florida, a project to design and build floating nuclear power plants. His shipbuilding career includes 16 years at Newport News Shipbuilding, where he held various positions including Manager of the Machinery Division and Director of Production Control and Manpower Planning; and two years at The Electric Boat Division of General Dynamics, where he was involved in work on SEAWOLF (SSN 575). Previously he was a U.S. Navy Engineering Duty Officer, serving as Ship Superintendent at Mare Island Naval Shipyard and as a Type Desk Officer at the Ship Repair Facility Subic Bay. His marine career has involved the construction, repair, or engineering of many types of vessels, including nuclear-powered submarines and surface ships and conventionally powered ships from landing craft to aircraft carriers. Mr. Van Liere is a member of the Naval Submarine League, the U.S. Naval Institute, the American Society of Naval Engineers, and the American Society of Mechanical Engineers.

AUTHORS' BIOGRAPHIES

P.R. Alman BSE
BS in Naval Architecture and Marine Engineering, University of Michigan 1977. Naval Architect, Marine Consultants and Designers Inc., 1977-1985. Research Scientist, Ship Performance and Model Testing Department, Tracor Hydronautics, 1985-1988. Project Engineer, Naval Sea Systems Command, Surface Ship Combatants, Federal German Navy DDG-2, F122 class, 1988-1990. Presently Naval Architect, US Coast Guard, Naval Architecture Branch, Marine Technical and Hazardous Materials Division. SNAME Panel H-10 member since 1981.

D.W. Andrew BA
Don Andrew joined the Woolston Shipyard of Vosper Thornycroft (formerly John I Thornycroft) in 1965 as an electrical fitter on warship construction, following an apprenticeship with Central Electricity Generating Board. In 1970 he transferred to the shipyard design and drawing offices and for the next seven years was engaged on the design of ship systems, specialising in Power Generation and distribution, for numerous warships including Type 21 frigates and HMS Wilton the worlds First Glass Reinforced Plastic Minehunter. During this period he also obtained a degree in Electrical and Engineering Science. From 1977 he worked with the Iranian Navy on contract from Vospers as an electrical advisor, MK 5 destroyer refit programme returning to the UK in 1979 and the Controls Division of Vospers. During the next nine years Don Andrew, was involved with the preliminary and detail design of Marine Systems including the Type 23 Frigate and Single Role Minehunter Power Systems before entering into sales. In 1988 he joined the General Simulation division of Rediffusion as Sales Manager Marine Systems working on training requirements and their solutions. Don has also served for the last 22 years in the weapons electrical Branch of the Royal Naval Reserve and frequently spends time at sea as the W.E.O. of Mine Counter Measures Vessels.



Ir. F.D. van Baak MSc
Mr. van Baak was born in 1949 and received his master's degree in Electrical Engineering and Power Electronics in 1973, at the Technical University Delft. After one year on Scientific Assistancy at the T.U. Delft, he joined the Ministry of Defence in 1974 at the Electrical Engineering Department where he partly designed and tested the S-class-frigate electrical power system and some SCC-panels. From 1978 he was working as Head of the Automation Section and was one of the basic designers of the platform automation conception on the Walrus-class submarines and the M-class frigates. In 1987 he became Head of the Electrical Technology Division and after a major reorganization within the Directorate of Materials in 1989 he became his current position of Head of the Platform-Automation Division.

T. Babin
Mr. Babin joined TANO Marine Systems in July of 1984 as a Test Engineer. In February of 1986, Mr. Babin was promoted to Associate Systems Engineer and in November of 1987 promoted to Systems Engineer. For the past two years Mr. Babin has been Project Engineer for the LSD-41 Class Machinery Plant Control System (MPCS) with a total number of eight shipsets of equipment. Recently, Mr. Babin has been appointed Project Engineer of the T-AO 187 Class "MPCS" and the "Cargo and Ballast Control System" for a contract total of 15 shipsets of equipment.

D.M. Bagge B Eng (Hons)
Dave Bagge is Senior Software Engineer within the Technology Department of Hawker Siddeley Dynamics. He graduated from the University of Bradford with an Honours degree in Information Systems Engineering in 1988. In October 1988 he joined Combustion Engineering as a trainee engineer developing software and hardware for process control systems. In May 1989 he joined Hawker Siddeley Dynamics as software engineer. Since then he has worked on the development of configurable, re-usable simulator systems for application in industrial and marine environments.

D.G. Barr BSEE
David G. Barr is an engineer at Westinghouse Electric Corporation, Machinery Technology Division. He holds a Bachelor of Science degree in electrical engineering from Grove City College and is currently pursuing a Masters degree in industrial engineering at the University of Pittsburgh. He is a member of IEEE. For the past six years he has been working in the area of process control.

Captain R.K. Barr USN (Ret)
Capt. Bob Barr retired from the US Navy in February 1990 following 39 years of service, the last seven of which he served in the Pentagon as Head of the US Navy Surface Ship Survivability Office. Bob has extensive experience in all aspects of ship survivability, having spent his early years of naval service in the damage control and firefighting arena. His 20 years of at-sea service provided him with the opportunity to serve in every position from the firefighting hose team to Commanding Officer of two ships. Bob was provided the opportunity to set the pace for surface ship survivability in 1983 shortly following his arrival at CNO's Office. The direction and pace of today's programs are the result of his efforts throughout his Washington assignment.

G.E. Bell BSc MIMarE
Geoff Bell served in the Royal Navy as a Weapons Electrical Officer for four years and joined the Electrical Design Department of Vosper Thornycroft's Shipbuilding Division in 1977. He was the Chief Electrical Designer of the Southhampton Shipyard from 1986 to 1989, when he moved to MSC Solent Ltd, a subsidiary of Vosper Thornycroft, as the Consultancy Group Manager. In this position he has been involved in the development of electrical power control and monitoring concepts for future RN ships.

R.L. Bennett AASMT BSCS
Ross L. Bennett is a Principal Engineer for Sperry Marine Inc. (Charlottesville, VA), with previous employment at GE and Texas Instruments. He has a total of over 13 years experience, most of which has been spent in real-time software development in such diverse applications as utility plant control, automotive engine test systems, robotics, and token ring LANs. For the past four years, he has coordinated the implementation of an IEEE 802.5 standard real-time shipboard token ring LAN for use in integration of shipboard navigational equipment. Ross received his A.A.S. in Mechanical Technology from Broome Community College in Binghamton, N.Y., and his B.S. in Computer Science from Texas A&M University.

Dr. C.G. Biancardi DrNautSc
Dr. Carmine Giuseppe Biancardi is Senior Research Specialist at the Istituto Universitario Navale, Naples Italy and Visiting Professor at the Department of Math and Science of the U.S. Merchant Marine Academy, Kings Point, NY, USA. He holds a Doctorate in Nautical Science from the Istituto Universitario Navale, Naples, Italy. He has been Visiting Researcher at the National Maritime Research Center, Kings Point, NY and Visiting Lecturer at the Australian Maritime College, Launceston, Tasmania, Australia. He has taught at the Nautical Institute of Genoa, Italy and at the Istituto Universitario Navale, Italy. His primary fields of research are Numerical Calculation of Hydrodynamic Coefficients of Ship Hulls, Maneuvering Indexes, Ship Controllability, Ship Maneuvering Simulation and application of Artificial Intelligence in the Maritime Industry. This research has been supported by grants from the National Council of Research of Italy (CNR), Ministry of Research and University of Italy, N.A.T.O., and S.I.F.P. (Southern Italy Fellowship Program) of USA. He is also a professional consultant. He is a member of the Society of Naval Architects and Marine Engineers (SNAME), the Society of Doctors in Nautical Science (ALDN), Italy, the Society of Naval Architects and Marine Engineers of Italy (ATENA) and the Italian Institute of Navigation.

V.P. Bingham FIMarE
Peter Bingham entered Royal Navy in 1946 and graduated as Chartered Engineer R.N.E.C. Manadon in 1949. Service as Engineer Officer in minesweepers, destroyers, cruisers, aircraft carriers and latterly submarines, until early retirement in 1959. Group Technical Manager/Director Brooke Bond & Co. Ltd. (Non-marine business). 1969, started Philadelphia Resins (UK) Ltd. and pioneered "Chockfast" Epoxy-Chocks for machinery alignment. 1974, onwards as Managing Director of Industramar Ltd., pioneered use of Schilling Rudders in sea going vessels, now responsible worldwide for the design and marketing of Schilling Monovec and Vectwin rudders. Fellow member of the Institution of Marine Engineers.

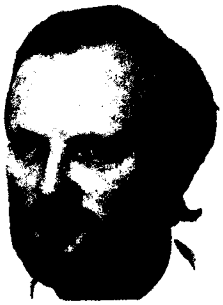
R.E. Bishop
Robert Bishop completed a Technician Apprenticeship with the Ministry of Defence in 1969 and served in HM Dockyard, Portsmouth until 1973. Following a period spent overseeing the building of Type 42 Destroyers he was appointed to Bath, where he was involved with the design and support of Ships Internal Communications Equipment. 1981 saw his promotion and appointment to the Future Machinery Control and Surveillance section, where he has been involved with the Assessment of Digital Demonstrator, T23 MCAS and SRMH SMS and MCAS. After promotion in 1989 he remained with the Future Machinery Control and Surveillance section and is now actively involved with the design and management requirements for an Integrated Platform Management System for future RN vessels.

Eur.ing. M.D. Blake BSc(Hons) CEng MIEE
After graduating from the University of Bath in 1983 Mike Blake worked in the defence electronics industry for two years. This was followed by four years with commercial hydraulics companies, designing electronic controls for servo hydraulic systems used in applications such as: papermaking, packaging food, and vehicle manufacture. He joined Vosper Thornycroft (Hydraulic Power) in 1988 and has been involved in the analysis and design of stabilizing systems for small yachts, SWATH vessels, and also on active suspension systems for tracked vehicles.

Drs. J.P.A. Boer MSc
Johannes (Hans) P.A. Boer is a research psychologist at the Ergonomics Group of the TNO Institute for Perception. He received his degree in experimental psychology from the University of Leiden in 1984. During his study he specialized in human problem solving and the reliability of human memory. His current interests are human error assessment and fault management in complex technical environments.

Prof.dr.ir. P.P.J. van den Bosch
Paul van den Bosch has been appointed professor in Control Engineering at the Delft University of Technology in 1988. His present interests include adaptive and robust control and CACSD applied to industrial processes, especially motion control systems. He has written about 100 international publications in the area of CACSD, electrical power systems and the control of satellites and ships.

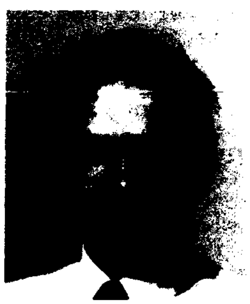
Lieutenant S.W. Braham BSc
Lieutenant Braham joined the Royal Navy in 1981 and following training at Dartmouth and Sea, he studied at the Royal Naval Engineering College, obtaining an Honours degree in Engineering. On completion of the Marine Engineering Application Course and further specialist sea training, he spent 2 years as the Deputy Marine Engineer Officer, HMS BRAZEN. He is currently studying for an MSc in Marine Engineering.



Ing L. van Breda
Leo van Breda graduated in 1968 with a BA degree in Electrical Engineering. In 1971 he joined the TNO Institute for Perception as a research engineer. His work was focused on the use of simulators for human engineering research. After a sabbatical year at DCIEM in Canada he was further specialized in system ergonomics using man/machine modelling techniques.

Dr. M.B. Broughton BSc MASc PhD PEng SMIEEE
Blythe Broughton received the BSc degree in Radio Physics and Mathematics from the University of Western Ontario in 1954. He completed a Master of Applied Science degree in Automatic Control Systems at the University of Toronto in 1958. He received the PhD in Electrical Engineering from Queen's University at Kingston in 1971; his thesis research dealt with adaptive PFM control systems. In 1960, he joined the Department of Electrical and Computer Engineering at the Royal Military College of Canada where he is now Professor. His research interests include the areas of instrumentation, measurement and control, power electronics and computer simulation of dynamic systems.

Lieutenant (N) G.S. Brown BEng
Lt(N) Glen Brown graduated from The Royal Military College of Canada (RMC) in 1986 with a BEng in Mechanical Engineering. Following Phase VI application training in HMCS PRESERVER, he served in the control system projects sub-section in the Directorate of Marine and Electrical Engineering NDHQ, Ottawa. During the summer 1990 he assumed a position as lecturer/masters student in the Mechanical Engineering Department at RMC.



R.G. Bryant BSc(Eng) MIEE RCNC
Richard Bryant graduated in 1970 with an Honours Degree in Electrical and Electronic Engineering. He initially worked for British Aerospace conducting studies into radio path propagation prediction techniques for satellite and terrestrial systems. After joining the MOD in 1975 he worked on Electromagnetic Compatibility testing and standards and in the test organisation for submarines after refitting. Between 1980 and 1985 he worked in the project for the design and build of the Royal Navy's Seabed Operations Vessel with responsibility for the electric propulsion and control systems. Since 1985 he has worked in his current post with responsibility for design and support of steering and stabiliser systems, damage control and surveillance systems and a range of instrumentation.

N.J. Bura BEng PEng
Mr. Bura graduated from Carleton University in Ottawa with a BEng in Electrical Engineering. After graduation he worked for the Department of Transport in the Airport Facilities branch before joining the Department of National Defence in 1975. He has held positions in power generation, marine systems engineering, electro-chemical and power distribution systems. He is currently the senior engineer in the Electrical Power Distribution Systems Group.

Dr. R.S. Burns BSc MPhil PhD CEng MIMechE
Served engineer apprenticeship at Lucas Aerospace and was subsequently appointed Development Engineer. 1965 moved to British Oxygen as a Project Engineer and in 1968 became Chief Development Officer at Evered and Co. 1970 moved to Polytechnic South West; currently Principal Lecturer for control and instrumentation in the Department of Mechanical Engineering. Major research interests include control and guidance of marine vehicles, mathematical modelling and computer simulation, and computer-aided-engineering. 1987 appointed Research Coordinator for the Institute of Marine Studies at Polytechnic South West. Founder member of the Ship Control Research Group and of the South West Marine and Industrial Control Consortium. Author of 35 Papers/Publications. Corporate Member of the Institution of Mechanical Engineers.

A.M. Burt
Adrian Burt has been involved in various aspects of the design and development of the Ship Manoeuvring Systems for the Single Role Mine Hunter, and is now Project Engineer for this and other position control system projects. He joined Vosper Thornycroft Controls Division in 1985 after experience in the marine seismic research and uninterruptible power supply design fields. Since joining VTC he has been involved in various projects for the Royal Navy including the Type 23 Frigate Main Electrical Power System and Machinery Control and Surveillance System.

F. Butscher Dipl Ing (FH)

Born:	1943
Education:	Highschool and College, bachelor degree of electronic engineer
Employment:	MTU since 1968
Main Subject:	Engine Control System for Marine, Tank, Locomotive and Gen-Set applications
Hobbies:	Sailing, Skiing, Hiking

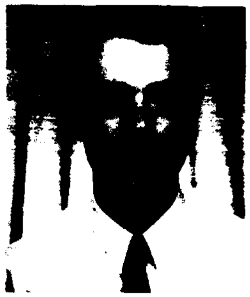
S. Calisal
No details available at time of publication.

Dr. M. Capecchi DrNautSc
Dr. Massimo Capecchi is a Full Professor of Navigation at the Nautical Institute of Rome, Italy. He holds a Doctorate in Nautical Science from the Istituto Universitario Navale, Naples, Italy, a Master Mariner degree from the Nautical Institute of Naples, Italy and a national teaching qualification in Navigation and Naval Architecture from the Ministry of Education of Italy. He has taught at the Nautical Institute of Porto S. Stefano, Italy and at the Nautical Institute of Naples, Italy. He delivered some papers on the application of experts systems in the maritime industry. He is member of the Italian Institute of Navigation.

L. Carroll BSE MSE
Mr. Carroll holds a BSE in Naval Architecture and Marine Engineering from the University of Michigan and an MSE in Mechanical Engineering from the University of Maryland. Upon graduation in 1975 he was employed by PDI CORP. where he remains today as the manager of the Systems Analysis Department. His major areas of interest include simulation and dynamic analysis of ship machinery and control systems and shipboard testing and analysis of these systems. He has conducted extensive dynamic analyses of systems involving gas turbines, diesels, combined cycles, steam, controllable and fixed pitch propellers and a variety of transmission systems.

Dr. D.B. Cherchas BASc MASc PhD
Dr. Cherchas is currently a Professor in the Department of Mechanical Engineering of the University of British Columbia, Vancouver, B.C., Canada. His interests are in the areas of adaptive control, estimation and robotics.

K.R. Chilvers MSc
Keith Chilvers has worked at the ADMIRALTY RESEARCH ESTABLISHMENT since 1967, being employed in the Metallurgy, Acoustics, Hydraulics and Machinery Control Sections. He obtained, by day release, MSc degree in Computer Science from the City University London in 1980. He was responsible for all computing aspects of the Evaluation Centre which was developed, for the Digital Propulsion Demonstrator project, between 1978 and 1981. He has recently performed a similar role for the Assessment Facility developed for the Type 23 Machinery Control and Surveillance system.

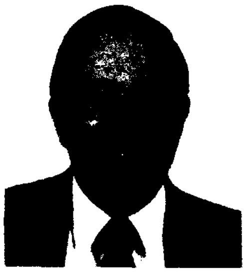


J. Chudley BSc (Hons)
1980-1984: A four year Mechanical Engineering Apprenticeship with a Marine Engineering Company. Experience gained in Design Drawing Office, being solely responsible for both design and development of sterngear and construction of a Propeller Characteristics computer programme.
1984-1988: Attended Plymouth Polytechnic and obtained a first class honours degree in Nautical Studies, specialising in Naval Architecture and Navigation/Hydrographic Surveying. On completion of the degree gained the Sir Francis Chichester award and the South West Joint Branch of RINA and IMarE award for Naval Architecture.
1988-1989: Re-employed by the same Marine Engineering Company as a Technical Sales Executive responsible for a small team of sales personnel and for customer liaison and subsequent sizing and design of propellers and sterngear. In the early part of 1989 the opportunity arose at Polytechnic South West (formerly Plymouth Polytechnic) to undertake full time study towards a Phd looking into the areas of ship modelling and collision avoidance.
1990: Employed as a full time lecturer in Marine Technology.

M. Clarke BSc CEng MIEE
In 1968 Mick Clarke joined Decca Radar as Assistant Engineer in Marine Radar. In 1970, he joined Vactric Control Equipment as a Development Engineer on Optical Encoders. (Vactric Control were taken over by Muirhead plc in 1972). From 1977-79 he was Senior Project Engineer (Stabilisers) and in 1979 became Chief Engineer (Systems). In 1982 he was appointed Engineering Director and his responsibilities are for Engineering Design and Development with special project responsibility for the Torque Motor Programme.

Dr. W.I. Clement PhD
William I. Clement received the B.S. degree in Systems Engineering and Mathematics from the United States Naval Academy in 1980 and the Ph.D in Electrical Engineering from the University of Virginia in 1989. From 1980 to 1985 he served as a helicopter pilot in the U.S. Marine Corps. Since 1989 he has been an Assistant Professor in the Weapons and Systems Engineering Department, United States Naval Academy. His research interests include stereo vision and applications of robotics and machine vision in manufacturing systems.

S.W. Colliss BSc AIMechE
Steve Colliss joined Vosper Thornycroft in 1983 as a graduate apprentice after completing a sandwich degree in Mechanical Engineering. On completing training his first post was with the Controls Division of Vosper Thornycroft which involved writing software for their ruggedised computer based on the Intel 86 family of components. He later joined Hydraulic Power and after two years as the Business Development Manager he is now a Project Engineer responsible for stabilizers and bowthrusters.



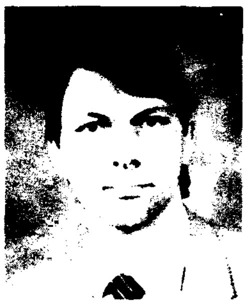
S.J. Connors BS
Received BS Applied Physics from Hofstra University. Completed graduate courses in Physics, Mathematics, EE and Computer Science Departments at University of Maryland and Johns Hopkins University. Thirty five years of related engineering experience (10 years with private industry, 20 years with the Johns Hopkins University Applied Physics Laboratory and 5 years with the Naval Ocean Systems Center).

R.E. Conrad BES ME MS
BES and ME in Mechanical Engineering, Brigham Young University, 1971. MS in Ocean Engineering, Massachusetts Institute of Technology, 1978. Employed by Naval Ship Engineering Center, Fluid Dynamics Branch, 1971 to 1979. Employed by Naval Sea Systems Command, Hull Form and Hydrodynamics Division, 1979 to present. Member of Society of Naval Architects and Marine Engineers, 1973 to present; member of SNAME H-10 Panel (Ship Controllability) 1981 to present.

T. Crampin BSc(Hons) DPS MErgS
Tex Crampin completed an honours degree in Ergonomics at Loughborough in 1978. He worked at Marconi Avionics on the EH-101 sonar suite until 1982 when he joined Link-Miles to set up a human factors group specialising in the definition of training requirements for simulation. In 1986 Mr. Crampin formed his own consultancy, Liveware, specialising in human factors. Since then, Liveware has devoted its efforts to the practical application of human factors in the design of military equipment. Projects include the design of future ship control centres, the design of a training programme for the Royal Norwegian Navy's new Ula class submarine and, more recently, an ergonomics evaluation of the Type 23 Ship Control Centre. Liveware's latest work is focusing on the specification of human factors in order to inject human factors considerations early into the Statement of Technical Requirement. This work has been directed at future frigates and the future SSN20 Nuclear submarine Operations Complex.

H.J. Crooks
Harry J. Crooks was elected as Chairman of the International Marine Simulator Forum (IMSF) at the Joint International Conference on Marine Simulation and Ship Maneuverability in Tokyo, Japan in June of this year. The (IMSF) is an organization composed of members dedicated to providing assistance to operators and users of ship simulators in order to use simulation most effectively to study, analyze and solve problems of ship operations. Prior to Mr. Crooks being elected Chairman, he was a Regional Representative for North and South America. He served in that position for three years. Mr. Crooks is presently the Director of the School of Engineering and Navigation and the Maritime Training and Research Center and President of the Toledo Chapter of the Propeller Club of the United States. The Maritime Training and Research Center houses a shiphandling simulator, engineroom simulator and radar simulator. Mr. Crooks has been involved in both training and research for the past six years. Some of the Center's research projects have included Port of Basque in Newfoundland, So Au Kang in Taiwan and, most recently, work on the ports of Cleveland and Lorain for the Ohio Steel Futures program.

Dr. M. Cuneo
Degree in Applied Mathematics in 1973 at Genoa University. Scientific Researcher at Institute of Ship Automation of the Italian National Councils of Researches in Genoa since 1976. Main research activity: Modelling and identification of marine vehicles and maritime traffic.

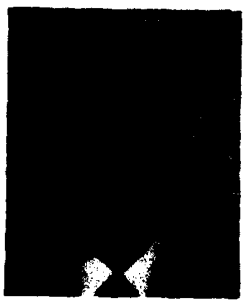


A.J. Davies BSc CPhys MInst PMBCS
Alan Davies obtained an Honours degree in physics at the University of Birmingham UK, in 1971. He joined Marconi as a design engineer specializing in Computers and working on Civil and Naval Radar Projects. His subsequent career took him into software, and he is at present a software consultant with Marconi Command and Control Systems. His experience includes the implementation of a number of major control and monitoring systems, ship and weapons system simulators. He is currently involved in a number of C.E.C. and UK D.T.I. sponsored studies in the areas of artificial intelligence, simulation and monitoring.

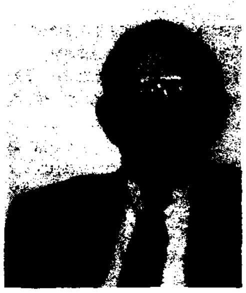
C. Davies BSc
Chris Davies joined Vosper Thornycroft in 1967 as a graduate apprentice after obtaining a degree in Mechanical Engineering from the University of Bristol. On completion of training he undertook various roles in the technical, production and commercial sections of the shipyard. This was followed by a period of seven years in the yacht building industry. He re-joined Vosper Thornycroft (Hydraulic Power) in 1981 as a Project Manager concerned with the manufacture of stabilizers for naval applications. Appointment as Technical Manager followed in 1985 and he is now responsible for the design and development of stabilizers, steering and hydraulic systems.

Dr. D.R. Dellwo DEngSci
Dr. David R. Dellwo is a professor of mathematics at the United States Merchant Marine Academy, Kings Point, New York. He holds a Doctorate in Engineering Science and a Master of Science degree from Columbia University (New York City). In addition, he holds undergraduate degrees from both Columbia and Carroll College (Helena, Montana). He has been a visiting member of the Department of Mathematical Sciences at Rensselaer Polytechnic Institute in Troy, New York, and a visiting scholar at The Technological Institute of Northwestern University in Evanston, Illinois. His research interests include perturbation analysis and bifurcation theory, marine applications of expert systems technology and computational techniques for the numerical solution of integral equations. He is a member The Society for Industrial and Applied Mathematics.

M. Dietzway ASEET
Mr. Dietzway has an associate in science degree for Electrical Engineering Technology from Delgado College and has attended the University of New Orleans. Mr. Dietzway joined TANO's Systems Engineering Department in 1976 as an Industrial Systems Engineer. Since then he has held the position of Systems Engineer for Industrial Systems, Senior Systems Engineer for Marine Systems, Project Engineer, Project Manager, and is currently the Supervisor of Systems Engineering. He has extensive experience in all stages of projects from the proposal stage through installation and final customer acceptance.

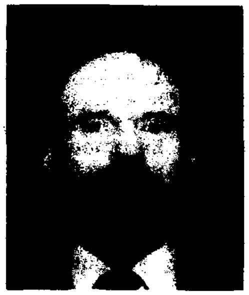


J. Donnelly
Mr. Donnelly is the Head of the Automation Systems Engineering Branch of the Instruments, Controls and Electric Power Department of the Naval Ship Systems Engineering Station. Branch responsibilities include In-Service Engineering and Test and Evaluation of the control and monitoring systems of Naval machinery. His affiliation with NAVSSES began in June 1962 in the capacity of student trainee. In June 1967, he obtained a B.S.E.E. at Drexel University, and immediately thereafter received his first professional appointment. Two years later, he was granted a M.S.E.E. from that same institution, where he currently holds the position of adjunct assistant professor in the Electrical and Computer Engineering Department.

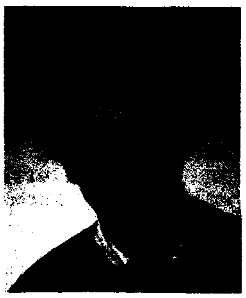


D.G. Douwsma
Following four years active duty with the U.S. Navy, Dow spent three years with a non-profit agency, then twelve years as an internal consultant to General Motors and to Pickands Mather (a natural resources firm). His last corporate experience was as Corporate Director of Training and Development for Midland Ross, a Fortune 300 company. Dow formed his first consulting practice in 1983. After selling three successful franchise operations he formed his current firm, Grafton Group, in 1988. His consulting practice is limited to Organization, Corporate Strategy/Implementation, the Maritime Industry and Human Resources Practices. He is the designer of Vessel Resources Management currently being used to train bridge teams using full-mission simulation. He holds an MBA from Baldwin Wallace College and is a full-time Ph.D. candidate in Organization at The Union Institute. He holds a continuing appointment as Associate Professor (adjunct) at Antioch University and volunteers as a tour guide at a reconstructed 1880's farm.

Dr. M.J. Dove MSc PhD CEng MRINA FRIN
Six years in Merchant Navy during which he qualified as a Navigation Officer, followed by service in the Royal Navy including operational tours in the Far East. Now Principal Lecturer in Marine Technology with responsibilities for administration of Marine Studies undergraduate courses in Science, Technology and Commerce. Head of Ship Control Group which undertakes research in marine navigation, track guidance, collision avoidance and mathematical modelling of ships.



S. Drew
Stanley Drew completed an Engineering apprenticeship in 1969 which started with the shipbuilder Simon Lobnitz on the Clyde and was completed in production engineering. After working on the development of measurement systems at Paisley College of Technology and obtaining an HNC in Mechanical Engineering he joined YARD LTD in 1978. Since joining YARD he has been responsible for the development of the company's instrumentation and condition monitoring services. He is presently a Project Manager in the Engineering Science and Assessment Department, having responsibility for multidiscipline data acquisition projects and condition monitoring projects in the offshore, industrial and Naval business areas.



H. Duetz MEE
Hans Duetz was born in The Hague, The Netherlands in 1959. After his graduation at the Control Laboratory in 1985, he joined a research project on adaptive autopilots for inland ships. This project has been financed by the Netherlands Technology Foundation (STW). In 1987 he became a member of the permanent staff of the Control Laboratory. His main research interests concern robust and adaptive control with application to ship steering.

R.J. Dupuis BSc
Richard Dupuis received a Bachelor of Science degree in Mathematics and Physics from Bishop's University in 1975 and a Bachelor of Science degree in Mathematics and Mechanical Engineering from Queen's University in 1979. From 1979 to 1982 he worked for Pratt & Whitney Canada as a gas turbine engine dynamics analyst and was involved in full scale engine testing. He joined GasTOPS Ltd. in 1982 and has been involved in a variety of projects related to the analysis, design and modelling of mechanical and electromechanical systems including marine systems. He is currently the engineering supervisor of the control systems group at GasTOPS Ltd.

D.W.East Dip Tech(Eng) CEng FIEE RCNC
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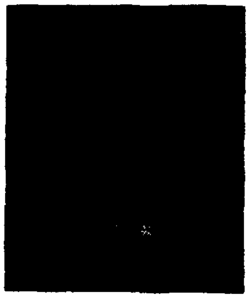
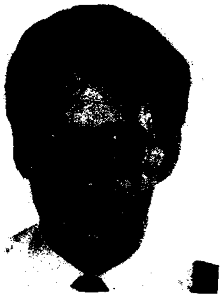


Dr. N. Fairbairn BSc PhD
Dr. Niall Fairbairn achieved his first degree in Electronics and Electrical Engineering from the University of Glasgow in 1985 (1st Class). After one years employment with Imperial Chemical Industries plc as a Control/Electrical Engineer, he began study for a PhD in Control Engineering at the University of Strathclyde. The research carried out during this time included application of advanced control techniques to a number of marine control problems. He obtained his PhD in 1989 and is presently employed as an accountant with Touche Ross & Co.

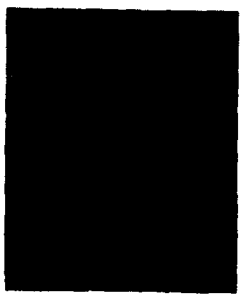
F. Fenucci
F. Fenucci is a Master mariner. He was born in Milan (Italy) in 1931. At the age of 33 he had already been in command of 7 tankers. During the following 26 years he has been involved in research, experiments and start-ups, all related to tankers and tanker terminals operation. During the last few years he has concentrated his studies and research on the symbiosis man-engine aimed at the maximization of efficiency and on ways to reduce the number of accidents due to human error. From 1958 to 1984 he was employed by Esso/Exxon.

Lieutenant Commander J.D. Forrest BSc MSc (Eng) CEng MIEE **RN**
John Forrest obtained a BSc in Engineering Systems and Control in 1973 from Huddersfield Polytechnic and an MSc in Control Engineering in 1987 from the University of Sheffield. Prior to joining the Royal Navy in 1976 he served an electrical apprenticeship with the Merseyside and North Wales Electricity Board followed by a period as a development engineer with Philips Domestic Appliances Ltd. He has served in HMS COLLINGWOOD, HMS SULTAN, HMS HERMES and the Royal Naval Engineering College, where he is currently a senior lecturer in Control Engineering.



Lieutenant Commander P.J.S. Fowler BSc MSc **RN**
Lieutenant Commander Peter Fowler Royal Navy graduated from the Royal Naval Engineering College in 1981 with a BSc in Engineering. After several sea appointments, he returned to the college to undertake the advanced marine engineering course and was awarded a MSc in 1989. He is currently serving with DGSM 532 at Foxhill, Bath.

G. Freestone BSc (Hons)
Gary has recently joined Vosper Thornycroft Controls Division to take up the position of Software Group Manager. Previous experience with the development of large software projects has been gained at Ferranti Computer Systems and Plessey Naval Systems. Gary's task at Vosper Controls is to use this experience to assist in the development of future platform management systems. Gary will be responsible for the planning and introduction of methods and tools to support the software development process.



V.D. Galindo BSE MSCS
Vincente Galindo received a BS degree in Engineering from the University of South Florida and an MS degree in Computer Systems from the American University. He is a manager for Business Development in Unisys Tactical Systems Division, Reston, VA. With over 15 years of experience in Control Systems, his areas of interest include process control systems, man-machine interfaces, and graphics and display systems for industrial and military applications.

D.W. Geer

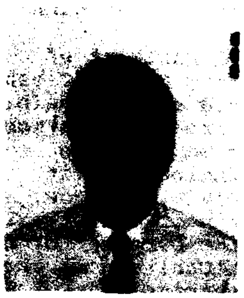
David Geer is a graduate of the U.S. Naval Academy and the Naval Postgraduate School with degrees in marine engineering and operations research. He is the Senior Program Manager for Combat System Survivability, NKF Engineering, Arlington, Virginia, and is responsible for the analysis, system engineering, and preliminary design of survivable combat systems and its associated total ship engineering dependencies. Previously, he was Technical Director for damage control systems, Martin Marietta Aero and Naval Systems, where he was responsible for the design and development of survivable shipwide automated damage control systems. He was on active duty with the U.S. Navy for 20 years. Ship assignments aboard destroyers and cruisers included combat system officer, damage control officer, and engineer officer.

Lieutenant Commander P.A.H.C. Ginoux Defermon Ret.

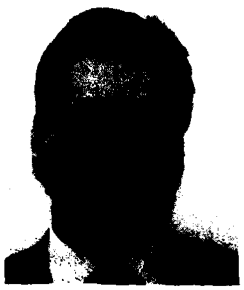
Paul Ginoux Defermon was borne in 1944 and was graduated from the French Naval Academy in 1967. He served initially as an ASW Officer on surface vessels then he specialized in data processing and operations research. He joined SINTRA ALCATEL (CGE Group) in 1981 as a marketing manager for surface ship sonars and transferred in 1988 to CGA-HBS to assume his present duties of military export sales manager. Among other activities CGA-HBS (a subsidiary of CEGELEC, CGE Group) is expert in servocontrols for naval, marine and tank turret applications.

Dr. J.A. Glen BSc PhD

John Glen is a Principal Consultant with YARD Ltd. He joined the company in December 1985 as a Consultant in the then newly formed Artificial Intelligence Group. He had previously spent 16 years working in Higher Education at Paisley College of Technology where he was course leader for the Mathematical Sciences degrees. In terms of his own education, John is a BSc (First Class Hons.) in Mathematics and Natural Philosophy and a PhD in Nuclear Structure Theory from the University of Glasgow. At YARD Ltd, he has technical responsibility for this development of Knowledge Based Systems and object oriented methods and management responsibility for both Expert Systems and Software Tool Business. He has been closely involved with the application of Knowledge Based Systems within the SCC since 1987 and has been YARD's Project Manager for the Expert Damage Assessor demonstrator reported in this project.



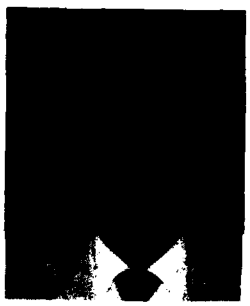
M.C. Glover
Michael Glover joined Hawker Siddeley Dynamics Engineering in 1978 after obtaining a Polytechnic Associateship in Electrical and Electronic Engineering from Liverpool Polytechnic. He has worked on the incorporation of digital systems for propulsion control for various classes of ships including corvettes and minehunters. He is currently responsible for the technical design of a distributed digital control system for ship-wide control and monitoring.



B.C. Goodkey BEng
Brian Goodkey graduated with a Bachelor's Degree in Mechanical Engineering from Carleton University, Ottawa, Canada in 1980. He joined GasTOPS Ltd., Ottawa, and was involved with the simulation of a complex thin film coating process at the National Research Council hybrid computer facility, the analysis and prediction of gas turbine engine performance, and the implementation of an automated design and analysis computer program for axial flow fans. In 1982 Brian joined JMAR Compressors Inc., Vancouver, B.C., designing, fabricating, commissioning and maintaining high pressure air and natural gas compressor packages for marine, industrial, and automotive refueling applications. Brian returned to GasTOPS Ltd. in 1986 to join the control systems group and is involved mainly with marine propulsion system analysis, simulation, design and testing.

Professor M.J. Grimble BSc MSc PhD DSc BA MIEE CEng SenMIEEE FIMA
In 1976, Dr. Grimble joined the Department of Electronic & Electrical Engineering at Sheffield City Polytechnic as a Senior Lecturer responsible for research. An industrial control applications grouping was formed in the Department and he obtained Readership in Control Engineering in 1979. The University of Strathclyde, Glasgow, appointed him to the Professorship of Industrial Systems in 1981, and he is now the Director of the Industrial Control Unit and Past Chairman of the Department of Electronic and Electrical Engineering. His group is concerned with industrial control problems, particularly those arising in the Aerospace, Wind Energy, Steel, Marine, Electrical and Gas industries. His research interests currently include self tuning and H_∞ robust control theory, multivariable design techniques and optimal control and estimation theory.

Professor Dr.-Ing. G. Grossmann
Please refer to the Chairmen's Biographies Section



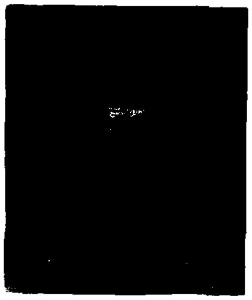
P.M. Grotsky AAS BSME
Peter M. Grotsky is currently employed at the Naval Sea Systems Command's Internal Combustion and Gas Turbine Engine Division as Deputy for Diesel Engine Programs and Logistics. In this capacity he is responsible for numerous Diesel Engine and Gas Turbine Improvement Programs currently ongoing. Peter has a Bachelor's degree in Mechanical Engineering from Pratt Institute. Peter has worked at the Naval Ship Systems Engineering Station (NAVSSES) before joining NAVSEA in 1978 as a project engineer responsible for the test and evaluation of Naval diesel engines, and also as a fleet diesel technical representative, providing troubleshooting expertise to the fleet world-wide.

H. Gruner BSEE MS
Mr. Henry Gruner, Executive Vice President and Chief Operating Officer of Dundics' Enterprises, Inc. of Annapolis, Maryland, received his B.S. in Electrical Engineering from the University of Pittsburgh, and M.S. in Technology of Management (with Distinction), Systems Analysis, MIS, and Computer Systems from American University. Mr. Gruner joined Dundics' Enterprises in 1986. He is responsible for management of business operations including strategic planning, contracts, engineering, production, sales, marketing, financial, and administrative management. Prior to joining DEI, Mr. Gruner was Division Director, Command and Control Electronics Division, TRIDENT Submarine Acquisition Project Office, Naval Sea Systems Command. He was directly responsible for one of the most successful electronics hardware/software acquisition efforts in the Navy Department. He has twenty years extensive experience in dynamic system design, hardware/software development, modeling and simulation, system engineering and integration, test and evaluation, and program/project management.

M.L. Hagins BS
Mr. Hagins has a bachelor's degree in marine engineering from the U.S. Merchant Marine Academy and is an associate member of the Society of Naval Architects and Marine Engineers. Mr. Hagins joined TANO in 1982 as a project manager. He was promoted to Systems Engineering Manager in early 1984 and later that same year was promoted to Senior Project Manager. In early 1989 Mr. Hagins was promoted to Director of Project Management and Engineering. In September of 1989, Mr. Hagins was appointed to be Vice President of Project Management and Engineering.

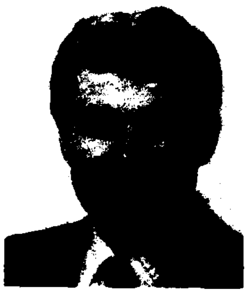
G. Hardier Doct
Georges Hardier was born in Paris, France, in 1957. He graduated in Electrical Engineering with automatic specialty degree in 1980, in Toulouse. He completed his doctoral thesis in 1984 and joined the Automatic Department of ONERA/CERT. His research interests are in filtering, identification and control techniques, currently applied to marine systems.

G. Hardwick
Please refer to the Chairmen's Biographies Section



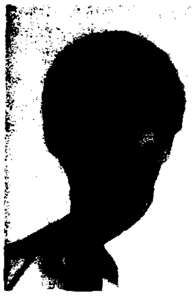
J.A. Harrison MA (Cantab) CEng MIEE MBCS
With a Cambridge engineering degree, John joined Sperry in 1966 working on control systems and simulation. In 1970 at Ferranti he led a submarine AIO/Fire Control project. He then formed a team working on displays design, application of speech technology and image simulation for trainers. He was consultant to many naval system projects. In 1987 he joined Sema Scientific and is currently Systems Technology Group manager, responsible for collaborative R&D programmes. During 1988 he was seconded to the team which won SSCS, the Type 23 command system. He defined MMI policy and introduced a Human Engineering Plan. He serves on professional and advisory bodies and has given papers on many topics relating to the human use of systems.

Professor Dr. K. Hasegawa PhD MS BS
Prof. Kazuhiko Hasegawa received the BSc, MSc and PhD degrees all from Osaka University, Japan in 1974, 1976 and 1982 respectively. He is currently an associate professor in the Department of Naval Architecture and Ocean Engineering, Osaka University. He did and does research mainly on estimation and evaluation of ship manoeuvrability, automatic control of ship operation and man-in-the-loop analysis utilizing a ship handling simulator, in Hiroshima University during 1976-1983 and in Osaka University after then. His current interests lie on knowledge-based simulation of ship operation and expert system on layout design problems.



M.I. Hawken BSc CEng MIEE
Mike Hawken joined the Ministry of Defence as an apprentice in 1963. Following service as a calibration technician, he graduated from the University of Strathclyde, Glasgow, in 1977 with a BSc Honours Degree in Electrical and Electronic Engineering. As a professional engineer he worked on two naval strategic weapon system projects, where he helped design land based missile test and storage facilities. He transferred to MOD(PE) joining the Naval Equipment Design for Through Life Cost (DTLC) Project in 1982, becoming project Manager of the DTLC project in 1984. He joined the Director General of Marine Engineering in 1986, where he is responsible for the formulating design and engineering standards for surface ship Machinery Control and Surveillance Systems.

Dr. A.J. Healey BSc(Eng) PhD PE
Please refer to the Chairmen's Biographies Section



R.S. Hebden BSEG
Roger S. Hebden is a senior software engineer for PDI Corporation. He has worked in the design and development of embedded control systems using Ada since 1984. Prior to joining PDI in 1987, he worked for Westinghouse Electric and Burroughs Corporation. His research interests include software development productivity and quality, real-time systems and Ada. Mr. Hebden received a BS in computer science from Bucknell University in 1983 and is currently pursuing a MBA in information systems at the University of Maryland, College Park. He is a member of the ACM.

Captain H.O.G. Hederström
Captain Hederström, is a Master Mariner and certified Marine Engineer from the Marine College, Gothenburg. He has also studied Ship's hydro mechanics at Chalmers University of Technology and Commercial Law at the University of Gothenburg. He has served as a Chief Officer in tankers 20.000 tdw - 278.000 tdw and as a Master of two Ro-Ro vessels. Since 1977 employed as a Pilot at Gothenburg Pilot Station. Since 1982 he has lectured in the training programme for Swedish Pilots. In 1983 he founded Hederström Nautical Consultancy AB, dealing with bridge procedures and design, navigational safety and shiphandling. He has published various articles on Bridge Procedures and Shiphandling and been a director of a training film regarding Shiphandling with tractor tugs. He is a member of the International Maritime Lecturer's Association, the Nautical Institute and the Royal Institute of Navigation.

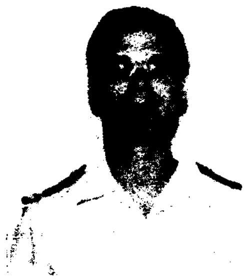
L.W. Himmler BS MS BA
BS in Naval Architecture and Marine Engineering, Webb Institute of Naval Architecture. MS in Environmental Engineering, Johns Hopkins University. BA in Art, University College, University of Maryland. Three years active duty in the Navy Civil Engineer Corps at the Naval Amphibious Base, Coronado. Thirteen years in Preliminary Design, Central Technical Division, Bethlehem Steel Corporation, Sparrows Point. Three years as NAVSEA Ship Design Manager for BB 61 Class. Presently NAVSEA Head Electrical Engineer, Steam Powered Surface Combatants. SNAME Panel H-10 Member/Recorder since 1980.

Dr. T. Holzhüter
Thomas Holzhüter was born 1951 in Bremen, West Germany. He graduated with a diploma in applied physics in 1978 from Kiel University, where he also received the Ph.D. in mathematical economics in 1983 with a thesis on dynamic input output models. Since 1983 he has been with Anschütz & Co., Kiel, where he is currently the head of the department of basic research, which includes the scientific computation center. The main activities have been in the development of the control and identification algorithms for an adaptive autopilot and a high precision track controller for ships. The current activities still comprise improvements of the track controller concerning both the modelling of ship dynamics and designing an especially robust controller. Since some time he is engaged in the development of an autopilot including roll reduction and in the problem of voyage optimization for ships. He serves as a part time lecturer for control theory at Kiel Polytechnic.

Ir. D. ten Hove
Ir. D. ten Hove was born in 1960, Kampen, The Netherlands. Received his masters degree in applied mathematics from the University of Twente, Enschede, The Netherlands, in 1985. Was involved in the modelling of air traffic services. Since 1986 engaged with the Maritime Research Institute Netherlands. Was involved in projects concerning the development of fast-time simulation models including the human operators, specification of modular ship manoeuvring models and safety studies for submarines using simulation techniques.

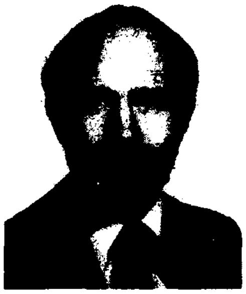
Dr. H. Imazu DEng
1968 - Graduated from Tokyo University of Mercantile Marine
1987 - Received the PhD. degree in naval architecture from Tokyo University
1972 - Joined the faculty of Tokyo University of Mercantile Marine
1990 - Appointed professor of the Department of Maritime System Engineering
Affiliation: Japan Institute of Navigation, Society of Naval Architects of Japan

Dr. M. Inaishi DEng
1984 - Graduated a graduate school of Mechanical Engineering, Kyushu University. Received a doctor's degree in Engineering.
1985 - Appointed lecturer of the Department of Transportation Engineering, Tokyo University of Mercantile Marine.
1986 to present - Appointed associated professor of the Department of Transportation Engineering, Tokyo University of Mercantile Marine.
Affiliation: Japan Institute of Navigation, Japanese Society for Artificial Intelligence, Japan Society of Mechanical Engineers, Heat Transfer Society of Japan.

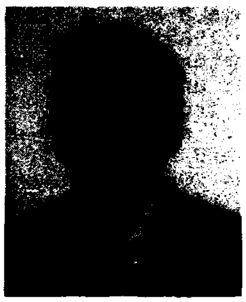


Lieutenant(N) K.R. Isnor BEng MEng
Ken Isnor attended the Royal Military College of Canada, where he graduated with a B Eng in 1982. He then entered the Navy and in 1985 completed his Engineering Certificate of Competency, enabling him to be an Engineering Officer onboard HMC Ships. Subsequent appointments included Engineering Officer in support of ship refits at dockyards in the Montreal area and Project Officer at Pratt and Whitney, Canada and CGE in Bromomt Quebec. In the Fall of 1987 he began his masters degree in Instrumentation and Control Engineering at the Royal Military College of Canada which he completed in the spring of 1989. Presently he is serving as the Machinery Control Projects Officer in the Directorate of Marine and Electrical Engineering in National Defence Headquarters, Ottawa.

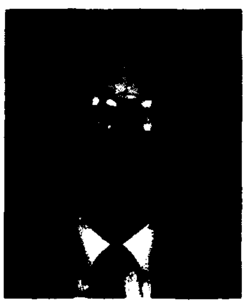
R. Ives CEng MIMarE MRINA FRSA
Mr. R. Ives completed his engineering apprenticeship with Shell Tankers(UK) Ltd and sailed as an engineer officer until 1980. In 1980 he obtained his Extra First Class Certificate and joined Shell International Marine Ltd as a project engineer in the new ship construction division until 1982. He is currently a project engineer in the Engineering and Development section of Shell International Marine Ltd and is involved in many aspects of marine engineering including safety and fuel related work.



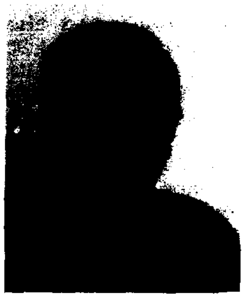
S. Jeanes BSc(Hons) MSc
Stephen Jeanes leads the Control Engineering practice at Cambridge Consultants Limited, who have been active in supporting naval design activity for many years. As a Control Engineer Steve's interests are in methods to improve system performance in both military and civil applications from specification to assessment. After receiving a B.Sc (Hons) in Physics from the University of Manchester, Steve spent two years teaching as a volunteer in Nigeria, before returning to take an M.Sc in control engineering again at Manchester University. After a period involved in the process control industry, Steve joined Cambridge Consultants Limited in 1984 and has since been involved in many projects involving control engineering methods.



J.R. Jefferson MSCS BSEE
James R. Jefferson is currently the Manager of Software Engineering at PDI CORP., in Annapolis, Md. He is responsible for the application of software technologies to real-time embedded control and simulation systems. His background includes over 14 years of machinery control, instrumentation, and software application experience. Mr. Jefferson received an M.S. degree in Computer Science from the Johns Hopkins University and a B.S. degree in Electrical Engineering from the United States Naval Academy. He is a member of IEEE.



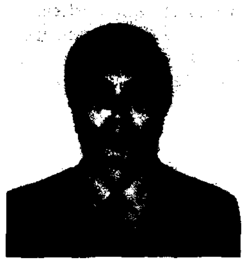
Dr. M.A. Johnson BSc(Hons) DIC MSc PhD FIMA
Dr. Johnson obtained his doctorate in Control Systems from Imperial College, London in 1978. Subsequently he worked as a research engineer with the then British Steel Corporation followed by a period with the British Gas Corporation. In 1982, he joined the University of Strathclyde to assist Professor Grimble with the formation of the Industrial Control Unit. He was made a Lecturer in 1986, Senior Lecturer in 1988 and Reader in Control Systems in 1990. His research interests cover many aspects of control design across a wide variety of industries. He is co-author with Professor Grimble of the 1988 book 'Optimal Control and Stochastic Estimation' published by John Wiley.



J.P. Jung Doct
Born in 1947, graduated in Aeronautical School in 1970, he obtained an Automatic Specialty degree in 1971 and his doctoral thesis in 1974. He joined the automatic department of ONERA/CERT in Toulouse in 1974 and his current research interests are in control techniques.

R.M. Kahn BSEE
Upon graduation from college, Mr. Kahn accepted employment with Naval Sea Systems Command as an Engineer-in-Training (EIT). After the EIT program Mr. Kahn was assigned as Project Engineer on the Data Multiplex System (DMS) program. His duties included management of DMS technical documentation, assure DMS readiness for Operational Evaluation, assure adequate maintenance philosophy implementation, and later he accepted the additional responsibility as DMS ILS Manager. In October 1987 Mr. Kahn also accepted the additional responsibility as Depth Detector and Depth Indicator Program Manager. After DMS transitioned from the Development Phase to the Production Phase Mr. Kahn was assigned as DMS Program Manager. He remains as DMS Program Manager today.

Dr. C.G. Källström DSc
Claes Källström received his Master of Science degree in Electrical Engineering in 1970, and his Doctor of Science degree in Automatic Control in 1979, both at the Lund Institute of Technology, Sweden. From 1970 to 1979 he was Research Engineer at Lund Institute of Technology. Since 1979 he has been with SSPA Maritime Consulting, Sweden, as research engineer, project manager, manager of business development, manager of Naval Systems, and from 1989 manager of SSPA Systems. His research interest is the application of modern control theory to marine structures, including ships, submarines, torpedoes and offshore rigs. System identification and adaptive control applied to ships and oil rigs have been a main research field as well as advanced use of computer simulation techniques. Claes Källström is responsible for the development and marketing of the Rudder-Roll-Stabilization system ROLL-NIX. He is the author of more than 20 papers presented in International Conferences and Journals.



Dr. K. Karasuno BEng MEng DEng
Dr. Karasuno was born in 1941 and completed the graduate course of engineering, Osaka University in 1969. His place of former employment was Kobe University of mercantile marine. He is concerned about the fluid dynamics of Ship maneuvering motion, ship control systems and marine simulator. Especially he works with rudder-hull interaction forces, yaw-rate wheel systems, onboard simulator/emulator, and fluid dynamics of ships moving with large drift angles.

Dr. M.R. Katebi BSc PhD MIEE CEng
After graduating with a 1st class Honours degree in Electronic Engineering at the University of Shiraz, Dr. Katebi Reza was appointed Control Design Engineer at Shiraz Power Station, Iran, where he developed a control system for a boiler. He then joined UMIST, first as an M.Sc. student in Advanced Control Theory and Practice, then as a Research Assistant for a collaborative project with Shell in the areas of modelling, identification and control of industrial boilers. In 1983, Dr. Katebi joined the Industrial Control Unit as a Research Fellow, where he specialised in the application of modern control theory to industrial control systems, in particular marine control. In 1987, Dr. Katebi was appointed Senior Engineer at Industrial Systems & Control Ltd, where he has been involved in modelling, simulation and control system design for a complex steel process, gas plant and worked on condition monitoring for nuclear reactors. He joined the Department of Electronic and Electrical Engineering at the University of Strathclyde as a Lecturer in Control and Manufacturing Systems in 1989. He also has an interest in biological control, marine control and the use of expert systems in process control. Dr. Katebi has many publications in the area of advanced control techniques as applied to industry.

Y. Kawamura BSEE
Born in 1935, graduated from Electrical engineering Fauculty of Kyoto University.

1958 - Kobe Shipyard, Kawasaki Heavy Industries, Ltd, mainly electrical and electronic systems on board submarines and submersibles.

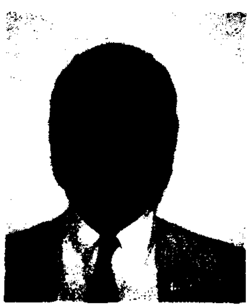
1978 - Prime Mover Division of same company, managing the control system of gas turbine propulsion plants for Japanese Navy under license agreement with Rolls Royce. Nearly 30 ships, 100 Engines were delivered. Author has been involved in the electrical and control systems for power generation plants using steam turbines, gas turbines, both heavy duty and aero-derivative and diesel engines. One of active HAM since 1958 from MHF up to UHF. (JA3 AUU)

Dr. R. Kim BS SM PhD
Dr. Kim received his B.S. degree in Mechanical Engineering from Columbia University, N.Y., in 1977; the S.M. and Ph.D. degrees in Mechanical Engineering from M.I.T., Cambridge, MA, in 1979 and 1985, respectively. Since 1985, the author has been with ARC Professional Services Group (formerly ORI, Inc.) working in the ship control and signal processing areas.

M.L. Klitsch BSME
Mr. Michael L. Klitsch graduated from the University of Maryland in 1982 with a Bachelor of Science Degree in Mechanical Engineering. He has worked at the David Taylor Research Center in the Hydromechanics Department as a Naval Architect since 1982. He is currently working as a Senior Project Engineer in the Full Scale Trials Branch of the Hydromechanics Department. Mr. Klitsch is the author of several reports detailing the powering and maneuvering characteristics of several classes of U.S. Navy ships. He is a member of the National Society of Professional Engineers and the American Society of Mechanical Engineers.

Dr.Ir. P.G.M. van der Klugt
Peter van der Klugt graduated in 1982 at the Control Laboratory of the Faculty of Electrical Engineering of the Delft University of Technology, specializing on the subject of rudder roll stabilization (RRS). Since then, he has been employed by the company Van Rietschoten & Houwens B.V. in Rotterdam. Until 1987, his main task was to develop an RRS autopilot in close cooperation with the Delft University of Technology and the Royal Netherlands Navy. In 1987, he received his Ph.D. from the Delft University of Technology. Currently, his interests are in the field of advanced autopilots and propulsion control systems for ships as well as in the field of Artificial Intelligence.

E.N. Knaggs
Edward Knaggs joined Shell Tankers (U.K.) in 1953, and was appointed Chief Engineer in 1968. He spent 6 years on LNG carriers before transferring ashore as Superintendent Engineer. In 1968 he joined Shell International Marine in the new projects division where he was responsible for control and surveillance systems on a range of new ship designs and particularly for software based systems for control of combined oil and gas fired, steam plant propulsion systems. He is currently involved with technical and operational audit and analysis of offshore vessels including those fitted with dynamic positioning systems.



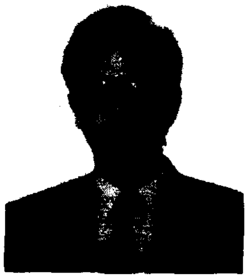
Dr. K.A. Knowles, Jr. PhD
Kenneth A. Knowles, Jr. received his BME degree in Mechanical Engineering from the University of Virginia in 1963, and the Ph.D. in Mechanical Engineering (Controls Group) from the University of Virginia in 1977. From 1963 to 1970 he served in the United States Navy as a qualified nuclear submarine officer, and as Chief Engineer Officer of two surface ships during the Viet Nam conflict. He is a Professor in the Department of Weapons and Systems Engineering at the U.S. Naval Academy, where he has been teaching since 1975. His research interests include applications of machine vision and robotics in manufacturing and automated systems. He has been a consultant for over ten years in U.S. Navy submarine trainers, fluid control systems, and NASA manipulator system simulators.

H.J. Korves BS MS MSEE
Harold J. Korves has been with Unisys since 1972 and has recently been responsible for design of the MHC-51 machinery/ship control system and the man-in-loop simulation system. Previously, he was responsible for requirements definition and system design of automatic ship control systems, trainers, strategic defense systems, and FBM Navigation System operational, simulation, and evaluation programs. Korves received the BS and MS in Mathematics, MSEE, and MS System Engineering from Polytechnic Institute of Brooklyn.

Dr. T. Koyama DEng
Please refer to the Chairmen's Biographies Section

J. Kriegsman BEE MSEE PE
Mr. Kriegsman received a Bachelors Degree in Electrical Engineering from the City College of New York in 1959 and a Masters Degree from Polytechnic Institute of Brooklyn in 1970. He is a licensed Professional Engineer. He started working in the field of navigation in 1959 at the Bendix Corporation in Teterboro, New Jersey, where over the next seven years he developed stability requirements for the gyro stabilized platform for the Pershing missile. He then worked one year at the EDO Corporation located in College Point, New York, where he designed stabilized networks for minesweeping sensors. Since 1968 Mr. Kriegsman has been employed with the Department of the Navy, first at the Naval Strategic Systems Navigation Facility at the Brooklyn Navy Yard, and then at the Naval Air Development Center in Warminster, Pennsylvania starting in 1973. He has performed various assignments in the field of navigation system analysis and design.

W.J. Kruijt Ir
Wouter Kruijt was born in Utrecht (Netherlands) in 1960. He joined the Royal Netherlands Navy in 1978. After receiving his engineering training at the Royal Netherlands Naval College and Delft Technical University (during which he worked on the PFBC EXSPENCO-project with NUCON Engineering) he served as a mechanical engineering and Damage Control officer on board supply vessels and S-class frigates. From 1986 till 1989 he worked for the Dutch MOD on platform automation for the M-class frigate project. In 1988 he graduated at Delft University on ergonomics of information presentation on VDU's in close cooperation with TNO/Institute for Perception (Diagnosis support in the MMI of the M-class frigate.) In 1990 he joined Van Rietschoten & Houwens and now works on IMCS concept definition.



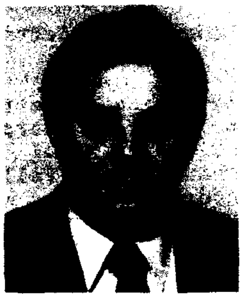
Professor N.P. Kyrtatos BSc DIC PhD
Nicholas P. Kyrtatos is an Associate Professor of marine engineering at the National Technical University of Athens (NTUA), Greece. He graduated in marine engineering from the University of Newcastle-upon-Tyne (1975) and obtained a PhD in mechanical engineering from the Imperial College of Science and Technology, London University (1979). He was a postdoctoral Research Associate at Imperial College from 1979 to 1980 and was a Visiting Professor in the Department of Mechanical Engineering, McGill University, Montreal, Canada from 1980 to 1982. He was served at the Greek Airforce Research Centre, Athens, from 1982 to 1984 and was Assistant Professor of marine engineering at NTUA from 1984 to 1988.

Lieutenant Commander N. Leak BEng MSc PEng
LCdr Nick Leak graduated from McGill University, Montreal in 1981 with a BEng in Mechanical Engineering. Following an appointment as Assistant Engineer in HMCS PROTECTEUR, he obtained an MSc in Marine Engineering at Royal Naval Engineering College, Manadon. Upon completion of his masters degree he served in the Directorate of Marine and Electrical Engineering NDHQ, Ottawa as the subsection head with responsibilities for diving systems, environmental protection, and auxiliary systems R&D. During the summer of 1990 he assumed the duties of Marine Systems Engineering Officer in HMCS PROTECTEUR.

M.E. Leblang BEE MSEE

Mr. Leblang received a Bachelors Degree in Electrical Engineering from the City College of New York in 1969 and a Masters Degree in Electrical Engineering from New York University in 1973. He was first employed in 1969 by ITT Defense Communications Division in Nutley, New Jersey, where he designed portions of microwave receiving systems. In 1971, he was employed by the Naval Strategic Systems Navigation Facility, Brooklyn, New York, where he was involved in the integration of precise navigation systems for deep ocean survey. This function was transferred to the Naval Air Development Center, Warminster, Pennsylvania in 1973, where Mr. Leblang performs various assignments in the field of navigation system development, integration, analysis and testing.

F.A. Lijewski BSEE



Mr. Lijewski has been associated with Westinghouse for over 30 years. During his career, he has held several professional and management positions in the field of: Instrumentation and Control; Electrical Systems; Artificial Intelligence; Reliability, Availability, Maintainability; and Safety and Hazard Analysis. Mr. Lijewski is currently Manager of Control Engineering at the Westinghouse Machinery Technology Division (MTD). MTD is an engineering service organization singularly dedicated to providing quality system engineering and related services to NAVSEA. Mr. Lijewski is a 1956 graduate in Electrical Engineering from the University of Pittsburgh. He has authored numerous articles involved with Instrumentation and Control, and Reliability Assessment. He has submitted several invention disclosures and is a member of IEEE and ASNE.

K.A. Lively OE MSEE
Following 10 years of service as an Electronics Technician, Mr. Lively earned his commission in the U.S. Navy in 1976. Sea duty assignments included the USS Lynde McCormick (DDG 8) and the USS Constellation (CV 64). In 1984, Mr. Lively received an Engineers Degree in Naval Architecture and Marine Engineering and a Masters Degree in Electrical Engineering from the Massachusetts Institute of Technology. Following graduate studies, Mr. Lively was assigned to the Naval Sea Systems Command in Washington, D.C., where he served first as Project Engineer for the DDG 51 Machinery Control System and later as Technical Director for the DDG 51. Mr. Lively retired from active duty in July 1989 and started work for PDI CORP., in Annapolis, MD, as Vice President of Engineering.

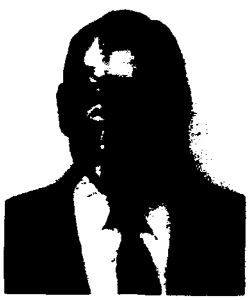
B.D. MacIsaac MEng PhD
Please refer to the Chairmen's Biographies Section

T.P. Mackey BSE MSE
Mr. Mackey has been active in the marine industry, principally at Hyde Products, Inc., for 30 years. He is a Vice President of the Society of Naval Architects & Marine Engineers (SNAME) and a Fellow of the Institute of Marine Engineers (IMarE). Mr. Mackey has authored several SNAME technical papers and is currently Chairman of the SNAME Ships' Machinery Committee and of the SNAME "Marine Engineering Control Committee". He is also of the author of the "Hull Machinery" chapter for the revised edition of "Marine Engineering" to be published in 1991.

A.E. Manfredi BSEE MSE
Upon graduation from college, Mr. Manfredi was commissioned in the US Navy and was assigned as Main Propulsion Assistant on board USS Berkeley (DDG 15). Mr. Manfredi then attended postgraduate school and, as an employee of Ketron, Inc., was assigned to the Destroyer Development Group (DESDEVGRU), Naval Base, Charleston, S.C. His primary duties at DESDEVGRU were to develop, test, and evaluate anti-ship missile defense tactics for NATO SEASPARROW and 5 inch guns. Mr. Manfredi has been with Rockwell International's Autonetics Marine Systems Division since 1977, and has been involved in programs which include the upgrade of the Adams (DDG 2) class destroyers, the Ship Systems Engineering Standards, and, since 1983, the application of the Data Multiplex System AN/USQ-82(V) to the Arleigh Burke (DDG 51) class destroyers.

D.J. Marshall CD BEng MSc PEng
Please refer to the Symposium Organization and International Coordinators Section

C.T. Marwood BSC (Eng) CEng MIEE
Tim Marwood graduated from London University during an apprenticeship with De Havilland, now British Aerospace. At Hawker Siddeley Dynamics he designed controls for aircraft gas turbines and propellers. With International Computers Ltd he developed mainframe logic and peripheral controllers, before returning to Hawker Siddeley to lead a study for the Canadian Patrol Frigate. Now Consultant in the Defence Systems Division, responsible for specifying and bidding distributed digital systems for monitoring and control of ships and land-based equipment. Mainly interested in Ship Platform Systems Integration and Automation.



K. Masuda

Education: Completed the whole course of the Pelagic Fisheries, Hakodate Fishery College in January 1952

Occupation: Joined the Hokkaido University. Was attached to training ship Oshoro-Maru in April 1953. Serving in that position up to this date.

Study: Consideration on the relation between oceanographic conditions and distribution of fishes (salmon, squid, sauly and tuna etc.) in the northern North Pacific and Indian Ocean

H. Matsumura
1979 - Graduated from Tokyo University of Mercantile Marine
1985 - Appointed lecture of Department of Navigation, Tokyo University of Mercantile Marine
1987 - Appointed associate professor of the Department of Navigation, Tokyo University of Mercantile Marine
Affiliation: Japan Institute of Navigation

L.B. Mayer BEng PEng
Laszlo Mayer with a B.Eng(Honours) degree in Electronics Engineering from Sir George Williams University, Montreal in 1973. Upon graduation, he was employed by Spar Aerospace, responsible for the design of spacecraft control electronics. From 1977 to 1980 he managed the development of aircraft instrumentation at Canadian Marconi. Since 1981, as the co-founder of Securiplex, he developed a highly successful control and monitoring system used extensively in marine and naval fire protection and damage control systems. Presently, as Vice-President of Securiplex, he is responsible for the development and marketing of the company's products. He is a member of the Order of Engineers of Quebec. He has previously co-authored a paper at the Seventh Ship Control Symposium.

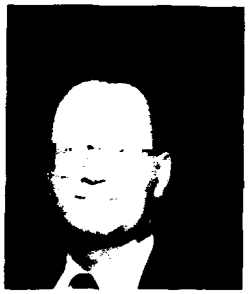
J.P. Mazurana MSIE BE
Mr. Mazurana has a M.S.I.E. from University of Pittsburgh (1989) and a B.E. in Electrical Engineering from Stevens Institute of Technology, Hoboken, NJ, (1976). Mr. Mazurana is a member of Tau Beta Pi, IEEE, and ASNE. Since 1984, he has been employed by the Machinery Technology Division of the Westinghouse Electric Corporation in Pittsburgh PA. and involved in various design studies and evaluations, including the DDG 51 Destroyer Machinery Control System. From 1981 to 1984, Mr. Mazurana was employed by the Gulf Research and Development Company, where he was involved with automation of automotive testing cells. Prior to 1981, he was employed by the Industry Electronics Division of Westinghouse, and involved with the development of commercial software and hardware for utility energy management control systems.

A.J. Mazzeo BE MA
Please refer to the Symposium Organization and International Coordinators Section

Dr. I.R. McCallum MA(Cantab) PhD

Dr. McCallum served in the Royal Navy for nearly 20 years, as a Weapons Engineer Officer, during which time he became interested in simulation at the Royal Naval College at Greenwich. He took his PhD in the manoeuvring of ships at the City University. Since leaving the Navy he has combined research and teaching at the University of Wales with directing a growing company which makes and operates ship simulators. His research interests are in the fields of simulation technology, port design and the manoeuvring and controllability of ships.

T. McClean BSc CEng MIEE



Tom McClean served an engineering apprenticeship with an aircraft company, followed by seven years in flight testing with responsibility for data gathering equipment, data analysis and reporting. National Certificates in Engineering were then complemented by a BSc in Electrical Engineering from Strathclyde University. He then joined YARD Ltd as a Design Engineer and progressed to Head of Section-Control Systems Design, leading a specialist team in the design, specification and assessment of complex control systems. His wide range of application includes studies in warship machinery control, damage control and system integration for the Royal Navy and several overseas navies, as well as commercial marine controls, controls on offshore platforms and industrial controls. His specialist consultancy activities have included control system design investigations following accidents at sea.

J.L. McCrea BSME MME

Jack L. McCrea is a principal engineer at Westinghouse Electric Corporation, Machinery Technology Division. He holds both a Bachelor of Science and a Masters degree in mechanical engineering from West Virginia University and the University of Ottawa, respectively. He is a registered Professional Engineer and has been working in the mechanical engineering field for 19 years. For the past six years he has been involved in the design and development of a Navy standard high pressure dehydrator and nitrogen generator.

G. McGar BS MEE
Greg McGar is the director of product development at TANO Marine Systems, New Orleans, LA where he has been employed since 1973. Mr. McGar has also been an instructor of electrical engineering at the University of New Orleans since 1975. He received his B.S. in physics from Louisiana State University in New Orleans in 1971 and master's degree from Tulane University in 1972. While at TANO, Mr. McGar has been involved in the design and development of commercial and military products and data acquisition and control systems including a laser guided training round for the Navy. As an electrical engineer, he has designed numerous electronic circuits for shipboard automation systems used for instrumentation, monitoring and control of shipboard propulsion plants and auxiliary machinery.

C. McNab
Clive McNab has been involved in the software industry for 10 years designing industrial and process control systems for robotics, factory automation and processing plant. Since joining Vosper Thornycroft Controls Division in 1987 he has been responsible for the development of software suitable for machinery control of marine systems. This has included projects for the Royal Navy such as the Type 23 Frigate and the *Sandown* class of Single Role Minehunter. More recently Clive has taken up the appointment of Technical Manager within the Controls Division to coordinate the design of machinery platform systems.

Dr. K.M. Miller PhD BSc
Five years as Scientific Officer with National Maritime Institute followed by further two years with British Maritime Technology as Development Engineer. Joined Polytechnic as Research Assistant in 1987. Worked with Ship Control Group investigating the use of Kalman Filtering and Automatic Guidance in Navigation. Appointed Lecturer in Hydrographic Surveying at Polytechnic South West in 1989.

A.T. Mitchell BEng CEng MIEE MIMarE
Arthur Mitchell received his initial training and development at Carimell Laird Shipbuilders, Birkenhead on warships, submarines and merchant vessels. He obtained an honours degree in electronic engineering in 1974. He joined Shell International Marine in 1978 as Project Electrical Engineer on a range of oil, gas and specialised offshore vessel newbuildings. In 1984 he was transferred to Shell Tankers (U.K.) as Superintendent Electrical Engineer and in 1986 started a 2 year secondment to Harland and Wolff Shipbuilders, Belfast, where he was responsible for developing the conceptual design of the MCAS system for a royal fleet auxiliary vessel. He is currently head of Electrical and Control Engineering at Shell Seatex with responsibility for the technical and operational audit and analysis of offshore vessels including those fitted with dynamic positioning systems.

Ir R. Moerman
Ir R. Moerman was born in 1955 and has studied computer instrumentation and avionics at the Technical University Delft, whereafter he began his career designing advanced computerized torque measurement systems for shipping and Industry. Later on he specialized in Monitoring and Control Systems at first with Berkel Research & Development and now at Van Rietschoten & Houwens. He has been working on the M-class frigates project for three years participating in information analysis and defining Man-machine system aspects. He has also participated in the R&H contribution to the Nato Frigate Replacement for the nineties project.

Lieutenant D.L. Mols RNLN
Diederik L. Mols is a lieutenant in the Royal Netherlands Navy. From 1981 until 1985 he studied marine engineering at the Royal Netherlands Naval Academy, Den Helder. After this period he studied a year at the Technical University of Delft, The Netherlands, where he focussed on control engineering. Since January 1988, after sea duty on board Standard frigates, he is Head of the Damage Control Section at the Royal Netherlands Navy NBCD School.

Dr. N. Mort
Neil Mort is a lecturer in the Department of Control Engineering at the University of Sheffield, UK. He took up this position in 1988 following a Medium Career Commission as an Instructor Officer in the Royal Navy. During his Naval Service, he spent a significant time at the Royal Naval Engineering College, Manadon where he was involved in control design for both surface ships and small diesel engines. His current research interests are applications of artificial neural networks to intelligent systems and the modelling, simulation and control of combined continuous/discrete systems.

J. Moschopoulos BSEE MSEE
Pease refer to the Symposium Organization and International Coordinators Section

M. Müller Dipl Ing (FH)

Born:	1954
Education:	Highschool and College bachelor degree of electronic engineer
Employment:	MTU since 1980
Main Subject:	Remote Control Systems for Marine applications
Hobbies:	Skiing, Hiking

A. Nazari BSChE
Abdi Nazari is a Life Cycle Manager at Naval Sea Systems Command, Gas Processing and Cryogenics Branch. He holds a bachelor degree in chemical engineering from Catholic University of America. He is a member of American Society of Naval Engineers. For the past five years he has been involved in the design and development of Gaseous Nitrogen Generator and other Gas Processing Systems.

J. Neilson BEng PEng MCASI
Jeff Neilson graduated from Carleton University in 1986 with a Bachelors degree in Mechanical Engineering and is currently working towards a Masters degree in Aeronautical Engineering on a part time basis. Jeff joined GasTOPS Ltd. in 1986 and currently works in the control systems group. He ha been involved in a variety of projects dealing with engine health monitoring and the analysis, design an simulation of marine propulsion and control systems.

Ing. W. van Nes

Willem van Nes was born in 1937. He completed his study in Naval Architecture at Technical College in Dordrecht in 1959. He joined Ministry of Defence, Bureau of Naval Construction in 1962. He was mainly involved in hydromechanics, hydroacoustics, ship design and control. From 1989 he is Head of Design Systems in Ship Design.

H. Oda BS

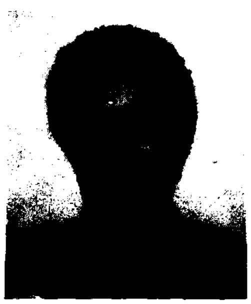
Hiroyuki Oda was born in 1950 in Japan. In 1973 he received the Bachelor's degree in physics from the Sophia University, Japan. Since 1973 he has been with Mitsui Engineering and Shipbuilding Corporation, Tokyo, and is currently the Sub Manager of the Akishima Laboratories (Mitsui Zosen) Inc. His research interests are in statistical control, ship maneuvering automation and time series analysis. He is a member of the Society of Naval Architects of Japan, the Society of Instrument and Control Engineering and the Marine Technology Society.

M.K. Paddock

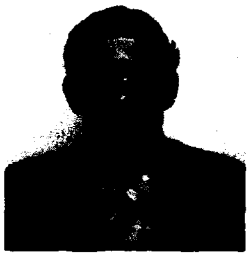
Mike Paddock served an apprenticeship with the Central Electricity Generating Board before joining the Ministry of Defence to work on electronic torpedoes. In 1972 he transferred to Bath where he worked on low power systems for T21 Frigates and County Class Destroyers. In 1977 he moved on promotion to the Engineering Services Department of the Clyde Submarine Base, where his tasks included the control and maintenance of services to alongside submarines and Base HV Authorised Person duties. Following a period writing Naval Engineering Standards in Bath, he moved to his present section where he is employed as a Senior Professional and Technology Officer responsible for in-service support of Main Propulsion and Auxilliary Machinery Control and Surveillance Systems.

I.A. Pagotto BEng MEng
Ivano Pagotto received his Bachelors (1983) and Masters degree (1985) in Mechanical Engineering from Carleton University in Ottawa, Canada. He joined GasTOPS Ltd., in 1985 as a member of the Control Systems Group and has been involved in a variety of projects dealing with the analysis, simulation, design and testing of mechanical systems and their controls, with emphasis in the area of marine propulsion systems and gas turbines.

V.B. Pandit BSE MSE
V.B. (Kisan) Pandit is currently employed at the Naval Sea Systems Command's Surface Ship maintenance Division as a General Engineer. In this capacity he is responsible for the Surface Ship maintenance Improvement Program (SSMIP), Maintenance R&D and Information Systems. Kisan has a Master's degree in Public Systems Engineering from the University of Michigan and a Bachelor's degree in Naval Architecture and Marine Engineering also from Michigan. He completed his basic training in Marine Engineering at the Marine Engineering College in India and then sailed as an engineering officer in the merchant marine. Kisan was employed at Navy's Military Sealift Command (MSC) as a Project Engineer responsible for T-Ship new construction programs before joining NAVSEA in 1987. Prior to joining the Navy, Kisan was employed by Trinity Industries' Equitable Shipyards Inc., New Orleans, La; in various capacities from that of a project engineer to the Engineering Manager.



Dr. F.A. Papoulias Dipl MSE PhD
Dr. Papoulias graduated from the National Technical University of Athens, Greece in 1983. He received his M.S.E. in Aerospace Engineering in 1986, M.S.E. and Ph.D. in 1986 and 1987 in Naval Architecture and Marine Engineering at The University of Michigan, Ann Arbor. He joined the Department of Mechanical Engineering at the Naval Postgraduate School in 1988. His primary research interests are in nonlinear dynamics and control, bifurcatian theory, and ship/submarine response and motion control.



E.J. Parrott CEng MIEE
Ted's early experience was as an electronic apprentice with the General Electric Company, followed by three years in the Royal Air Force on radio and radar systems. He then spent three years with Rediffusion Research specialising in high power audio transmission. He joined Muirhead Vactric Components in 1957 initially in the design of servo component test equipment. From 1965 to 1975, as a group engineer, he was responsible for the company's success in the field of specialised A/D and D/A converters of both servo and solid state types. Diverse applications included nuclear submarines and the reconnaissance pods of the Phantom and Harrier jets. From 1979 to date he has been employed in the Systems Department being involved in a wide variety of projects including analogue and digital ship stabiliser control systems for the U.S. and Royal Navies. Ted holds several patents, one for the first Royal Navy application of microelectronics.

Dr.ir. P.O. Passenier
Peter Passenier obtained a Master's degree in electrical engineering at Delft University of Technology in 1984. He joined the Control Engineering Laboratory at the Faculty of Electrical Engineering as a member of the scientific staff. In 1989 he obtained a Ph.D. degree on the thesis "An adaptive track predictor for ships". In September 1989 Peter joined the TNO Institute for Perception, the Ergonomics Research Section

Dr. A.M. Pechey BSc BA MPhil PhD
After graduating with a first class degree in Psychology, Alan Pechey completed M.Phil. and Ph.D. degrees in human information processing at Cambridge University. From 1985 to 1989 he worked for EFD Ltd as a senior consultant, principal consultant and projects manager. In addition to his management role, he carried out requirements definition studies and human factors audits of manned systems. He also advised on the interface design and user documentation for a new major C3I system and was responsible for the acceptance testing of these aspects of the system and for carrying out subsequent field usability studies. Recently, he left EFD to establish his own company, Caversham Consultants Ltd, providing consultancy in human factors and system psychology.

Commander R.C. Pelly MSc CEng MIMechE FIMarE **RN**
Commander Richard Pelly joined the Royal Navy in 1969. After training he undertook appointments at sea in HM Ships ANTRIM and INVINCIBLE obtaining in between an MSc. He served in DGME's Machinery Controls section and was then Marine Engineer Officer of HMS BRAZEN, a Type 22 Frigate. Afterwards he was the Director of Postgraduate Studies at the Royal Naval Engineering College, Manadon, and then Head of the Machinery Controls section at the Admiralty Research Establishment, West Drayton. In March 1990 he was appointed back to the aircraft carrier HMS INVINCIBLE as Marine Engineer Officer.

J. Perdok MSc
Jan Perdok was born in 1950. He received his Master's degree in Experimental Psychology from the University of Grormingen. He is specialised in statistical methods, human information processing and physiological psychology. Since 1982 he is working at MARIN. He is and was involved in port design studies, workload studies and the development of navigator/manoeuvring models. After a position as head of the R&D Department of Maritime Operations Division he is, since January 1990, deputy head of that same Division.

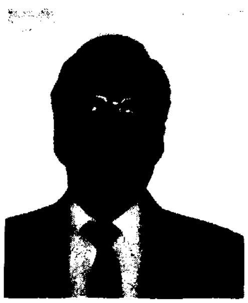
P. Perdon Eng
Pierre Perdon was born in 1963. Graduated in mechanical engineering in 1987, he began to work for STCAN in 1989. He is in charge of the sea trials of the free model of the French Nuclear Aircraft carrier.

M. Perre MA
Michael Perre received the M.A. degree in applied computer science from the University of Twente, Enschede, The Netherlands, in 1986. During 1987 he was associated with the Automation Centre for Weapon and Command Systems of the Royal Netherlands Army. Since the beginning of 1988 he is working as a research scientist at TNO Physics and Electronics Laboratory in the Command & Control Information Systems/Knowledge Based Systems Group.

A.C. Pijcke MSc CEng FIMarE
Please refer to the Symposium Organization and International Coordinators Section

M. Post BSEE PE
Mr. Post has a BS in EE from the Massachusetts Institute of Technology (1982), and is a licensed Professional Engineer in Pennsylvania. Since 1988, he has been employed by the Machinery Technology Division of the Westinghouse Electric Corporation in Pittsburgh, PA, where he has been involved in computer modeling, circuit analysis, reliability analysis and several design studies, including that of the DDG 51 Machinery Control System. From 1982 to 1987, Mr. Post was commissioned in the U.S. Navy where he attended the Naval Nuclear Power School and acted as Reactor Controls Division Officer aboard the USS South Carolina. While assigned to the USS South Carolina, he passed his Naval Nuclear Engineers Examination and developed a computerized exam bank for Naval Engineering Watch Station Examinations.

Lieutenant Commander D.C. Powell BSc(Hons) MSc CEng MIMarE **RN**
Lieutenant Commander Powell joined the Royal Navy in 1977. Initial basic officer training was at BRNC Dartmouth and in HMS FEARLESS and fleet training in HMS SHEFFIELD. In 1978 he went to the Royal Naval Engineering College, Manadon from where he graduated with a BSc. (Hons) degree in Naval Engineering in 1981. Further training as a marine engineer proceeded his appointment as the Deputy Marine Engineer Officer of HMS CARDIFF in 1983. He then returned to Manadon in 1985 where he read for an MSC in Marine Engineering. Following his graduation in 1986 he was appointed to HMS ARK ROYAL as Senior Watchkeeper. Lieutenant Commander Powell moved to his present appointment with the Director General Marine Engineering in 1988 where he is responsible for the future development programmes for both ship stabilisation and damage surveillance systems and equipments.



Dr. D.L. Prager BSc Eng MSc PhD CEng MIEE
After completing his first degree in Electrical Engineering, Dr. Prager embarked on research into System Identification and Self Tuning Control techniques which earned him a PhD from UMIST. He has subsequently worked in industry on the design and development of gas turbine, avionic and ship control equipment. Dr. Prager is currently the Product Manager for Control and Surveillance Systems at Sema Scientific. He is a past chairman of Professional Group C9 of the Computing and Control Division of the IEE and maintains an active interest in fault tolerant and safety critical systems as well as control system design.

R.L. Price BSEE
Roger L. Price graduated from Purdue University with a BS degree in electrical engineering in 1972. He has worked at the Naval Weapons Support Center, Crane as an electronics engineer since 1972. For the past fifteen years, Mr Price has worked in control system design. His design experience includes controllers for elevators, steering systems, gas management systems, oxygen generators, and machinery controls. Mr. Price has co-authored several papers on advanced control systems.

W.N. Pym
After a marine engineering apprenticeship, Mr. Pym served at sea for several years as a certificated engineering officer with the P. and O. group of companies. Coming ashore in 1961, for the next seven years he was involved in the application of marine controls, followed by sixteen years in aerospace, marine and process control instrumentation in the United States. Returning to the U.K. in 1984, he joined Racal Marine Electronics Ltd where he is a senior manager responsible for Racal-Decca ISIS marine automation.

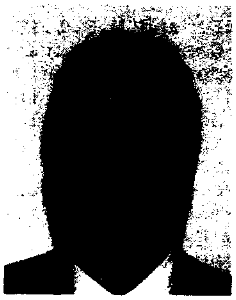
K.W. Reading
Mr. Reading joined Hawker Siddeley in 1959 initially working on the design of missile ground test sets and then industrial data loggers. He wrote and commissioned his first plant control program in 1968. He subsequently led the companies application of computers in the fields of mining, gas turbine engine control, and ship machinery control systems. Since 1980 he has held the position of technical manager in which role he is responsible for the development and company application of new techniques and technology.

W.A. Reinhardt BASc PENG
Mr. Reinhardt graduated from the University of Toronto with a B.ASc degree in Electrical Engineering. He worked for Computing Devices of Canada on the design and development of airborne navigational aid equipment before joining the Department of Nation^l Defence in 1965. He has held various engineering positions for shipborne radio navigation aids, electro-mechanical instruments, and power distribution systems. In 1980 he became the senior engineer responsible for shipboard electrical motor drives and electrical propulsion systems. In 1988 he was promoted to Head of the Naval Electrical Power Systems Group.

I.M. Ritchie MA (Hons)
Mr. Iain Ritchie completed an M.A. (Hons) degree in Psychology (1987) and a Diploma in Information Technology (1985) at the University of Glasgow. He went on to read for a Ph.d. in Machine Learning for Expert Planning Systems also at the University of Glasgow. He joined YARD's Artificial Intelligence Group in 1988 and has worked on knowledge based systems for damage control, the development and application of SYMTACTICS, YARD's battle modelling tool and the use of AI in Command and Control systems.

C.J. Robert BSCS BS
Mr. Robert started TANO Marine Systems in October 1987 as a Senior Software Engineer. Since this time, he has designed and coded the LAN, distributed database, and data acquisition modules for a propulsion control/alarm monitoring system for use on the Coast Guard's Polar Class Icebreakers. The target for the system whose primary design language is Ada, is an MC68020-based VMEbus system. In addition, he has designed and coded a multitasking operating system along with communication and application software for the new family of high-speed remote data acquisition units (named TANONet) for use in marine and SCADA systems. The computer used for these units is the NEC V25 processor and languages used are assembly language and C. Mr. Robert received a B.S. in Computer Science and a B.S. in Mathematics from the University of New Orleans in December of 1983.

Lieutenant Commander G.N. Roberts PhD MSc BSc CEng FIMarE MIEE **RN**
Lt Cdr Roberts holds a BSc in electrical engineering, a MSc in marine engineering and a PhD in control engineering. After joining the Navy in 1977 he has served in HMS COLLINGWOOD, RNEC Manadon (on a previous occasion) and the Sixth Frigate Squadron. He rejoined the staff of Manadon in 1983 where he is currently Senior Lecturer in the Control Engineering Department.



H. Robey BES MSEE
Mr. Robey received his BES, Electrical Engineering in 1972 and his MSEE in 1978, both from the Johns Hopkins University. He has spent his entire professional career at the David Taylor Research Center beginning in 1972 working on the Superconducting Electric Drive Program in the area of machinery system design and analysis. In 1984 he became Head of the Machinery Systems Engineering Branch with responsibility for machinery systems analysis and demonstration, and development of machinery monitoring and control systems. Presently, Mr. Robey is Head of the Systems Engineering Branch of the DTRC Advanced Machinery System Project Office which is providing systems engineering support for the Navy's Integrated Electric Drive Program.

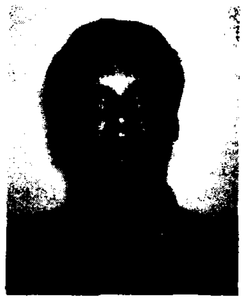
J.J.C.R. Rutten MSc
He received the MSc degree in electrical engineering and computer science from the University of Twente, Enschede, The Netherlands, in 1987. Since December 1987 he is working as a research scientist at TNO Physics and Electronics Laboratory in the Command & Control Information Systems/Knowledge Based Systems Group.

P.A. Salmon
Graduated as a Naval Architect in 1986. Pierre A. Salmon has been working for six years in the French Navy Surface Ship Design Division (DCN/STCAN/SDN). As a design manager, he is since 1986 in charge of the automatic steering and stabilization system (SATRAP) of Nuclear Aircraft Carrier "Charles De Gaulle".

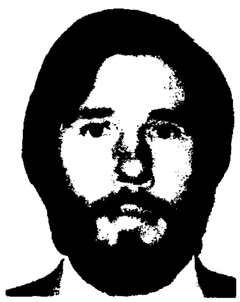
Dr.ir. H. Schuffel
Herke Schuffel studied naval architecture at the Delft University of Technology. After his military service he joined the TNO Institute for Perception in 1970 as a research engineer. His research was focused on workstation design and human behaviour in controlling slow responding processes. Since 1984 he is head of the Ergonomics Research Section. In 1986 he obtained a Ph.D. degree in social science on the thesis "Human control of ships in tracking tasks".

Dr. W.L. Schultz PhD PE
Dr. Schultz received the B.S.E.E. and M.S.I.E. (instrumentation) degrees from Case Institute of Technology in 1964 and 1967 respectively. His early career was devoted to medical engineering research both at Highland View Hospital and later at the CWRU School of Medicine in Cleveland, Ohio. His work produced several specialized medical instruments. He received the Ph.'D. in Electrical Engineering from Case Western Reserve University (CWRU) in 1979. Before joining Hyde Marine Systems, Dr. Schultz was a member of the Electrical Engineering Faculty at CWRU. His chief technical interests are the description and modeling of systems via the Ada computer language and the application of multi-microprocessor based systems to problems of automation and control. He has presented several conference papers in the areas of factory network simulation and selected applications of artificial intelligence.

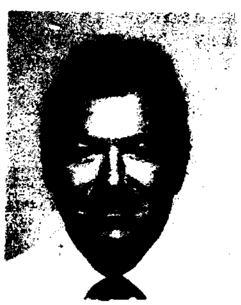
B. Scott Bsc MIEE CEng
Barry Scott served an apprenticeship in heavy electrical engineering. In 1971 he graduated with a degree in Electrical and Electronic Engineering from the Polytechnic of Sunderland. He joined the staff of the Polytechnic and undertook research and lecturing duties in control theory. In 1973 he joined Vosper Thornycroft (UK) Ltd as a Weapon System Engineer and was closely involved with the weapon system design of a number of vessels. His next appointment was as Project Engineer for an operations room simulator. In 1982 he joined Vosper Thornycroft Controls as the Simulation Manager and was responsible for simulations related to dynamic positioning, marine propulsion and power systems. In 1986 he was appointed Manager of the newly formed Marine Systems and Computing Division of Vosper Thornycroft (UK) Ltd. Currently he is attached to the Systems Group responsible for Product and Business Planning.



T.G. Scott BSEE
Timothy Scott graduated with a Bachelor of Science Degree in Electrical Engineering. He has been designing digital control systems at Naval Weapons Support Center, Crane for the past five and a half years. Mr. Scott is currently pursuing a master's degree in electrical engineering, and has co-authored several papers on advanced control systems. Mr. Scott is also involved in two IEEE working groups developing high speed communication protocols.



D. Stead BSc CEng MIEE
David Stead graduated in 1973 with a degree in Applied Physics from Hull University. From 1975 David worked on warship controls and the surveillance systems for Vospers Thornycroft Limited. This included leading the Type 23 Machinery and Surveillance System design teams. In 1988 he joined Sema (CAP Scientific) and worked on studies into Platform and Weapons Systems. The past eighteen months have been concerned with the ADAWS Improvement Programme Shore Development Facility for the Type 42 and CVSG's and also with linking systems to the Combat System Highway (NES1024). At present he is the Senior Consultant on Weapons and Platform Systems.



R.J. Stenson BSMarE
Mr. Stenson is the Head of the Full Scale Trials Branch, Ship Powering Division, David Taylor Research Center. He is a graduate of the State University of New York, Maritime College, and holds a Third Assistant Engineers License in the U.S. Merchant Marine. During his twenty-seven years of employment at DTRC, he has participated in or conducted trials on every class of submarine and most classes of surface ships currently operated by the U.S. Navy. He is a member of SNAME and ASNE.

Dr. A. Sugisaki DEng
1960 - Graduated from Tokyo University of Mercantile Marine
1983 - Appointed professor of the Department of Transportation Engineering, Tokyo University of Mercantile Marine
Affiliation: Japan Institute of Navigation; Japanese Society for Artificial Intelligence; Institute of Electronics, Information and Communication Engineers; Information Processing Society of Japan

Lieutenant Commander R. Sutton BEng(Tech) MEng PhD CEng MIMechE MIEE **RN**
Lieutenant Commander Robert Sutton Royal Navy holds the degrees of BEng (Tech), MEng and PhD from the University of Wales. He is also a corporate member of the Institution of Mechanical Engineers, and the Institution of Electrical Engineers. Since joining Royal Navy in 1976, he has served in HMS RALEIGH, the Fifth Frigate Squadron, HMS FISGARD and is currently the College Reader in Control Systems Modelling at RNEC, Manadon.

Dr. N.G. Swamy BE PhD PEng
Mr Swamy received his Bachelor's degree in Electrical Engineering from Bombay University, India and his post-graduate degree from Imperial College, London. He joined the Department of National Defence, Canada in 1970 and has been involved in design and project engineering of Naval power generation, conversion and distribution systems. He is currently the senior engineer in the Power Generation and Conversion Group.

Ir. C. van der Tak
Born in 1949. Took his degree in applied mathematics at the University of Technology, Delft, in 1970. Was engaged in the optimization of a nuclear reactor shield during his service with the Royal Navy. Involved in production planning projects during three years with the Netherlands Ship Research Centre, TNO. Since 1975 engaged with the Netherlands Maritime Institute, now MARIN. Was engaged several years with the Computer Aided Routeing of Pipelines in a ship's engine room. Was involved with the system design of an international traffic study and did other work in the field of applied mathematics.

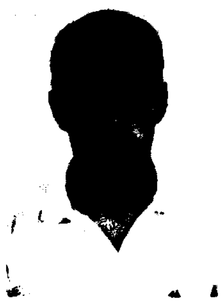
S.E. Tarrant BSc
Simon Tarrant joined Vosper Thornycroft (UK) Limited in 1975 after graduating from Southampton University with a BSc in Electrical and Electronic Engineering. He worked initially at the Controls Division where he was involved in real time software design for microprocessor based warship machinery control and surveillance systems. After a period as Software Development Group Head he became the Controls Division Technical Manager, a position he held until 1989. He is currently the General Manager of the Hydraulic Power Division.

B. Taylor BSc
Please refer to the Chairmen's Biographies Section

Dr. A. Tiano
After graduation in Applied Mathematics in Genoa University, he worked since 1973 until 1982 as a Scientific Researcher at the Institute for Ship Automation of Italian National Council of Researches in Genoa. He worked mainly in the field of modelling, identification and control of marine vehicles. Since 1987 he has been an associate professor of systems theory at Mathematical Department of Modena University and holds a cooperation contract with the Institute for Ship Automation.

Dr. A. Troiano DrNautSc
Dr. Antonio Troiano is a Full Professor of Meteorology and Oceanography at the Nautical Institute of Naples, Italy. He holds a Doctorate in Nautical Science from the Istituto Universitario Navale, Naples, Italy and a national teaching qualification in Navigation and Naval Architecture from the Ministry of Education of Italy. He has taught at the Professional Maritime School of Procida, Italy. He delivered some papers on the application of experts systems in the maritime industry. He is a professional consultant. He is the National President of the Society of Doctors in Nautical Science (ALDN), Italy. He is a member of the Society of Naval Architects and Marine Engineers of Italy (ATENA).

Dr. A. Trotta DrNautSc
Dr. Angelo Trotta is a Full Professor of Naval Architecture and Safety of Ships at the Nautical Institute of Procida, Italy. He holds a Doctorate in Nautical Science from the Istituto Universitario Navale, Naples, Italy and a national teaching qualification in Navigation and Naval Architecture from the Ministry of Education of Italy. He has taught at the Nautical Institute of Torre del Greco, Italy. His main fields of research are Maneuvering of Ships in Shallow Water and Safety of Ships. He also delivered some papers on the application of experts systems in the maritime industry. He is the National Secretary of the Society of Doctors in Nautical Science (ALDN), Italy.



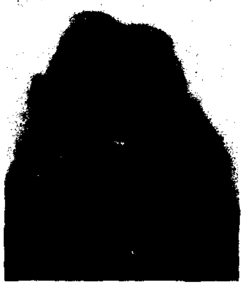
J. Tsolkas Dipl Eng
John Tsolkas graduated in marine engineering, from the National Technical University of Athens (NTUA) in 1986 and now works there as a Research Assistant in the Department of Naval Architecture and Marine Engineering. His research interests are applications of artificial intelligence (AI) in marine engineering and he is currently working towards a PhD in that area.

S. Tsuruta
1972 - Graduated from Tokyo University of Mercantile Marine
1977 - Graduated from the graduate school of Transportation Engineering, Tokyo University of Mercantile Marine
1977 - Joined the faculty of Tokyo Univ. of Mercantile Marine
1980 - Appointed associate professor of the Department of Transportation Engineering
Affiliation: Japan Institute of Navigation, Japan Physical Distribution Academy, Japanese Society for Artificial Intelligence

H. Uetsuki MEng
Hiroaki Uetsuki, Research engineer, IBM Japan, Yamato Laboratory. BS (1988) and MS (1990) from University of Tokyo in the field of naval architecture. Member of Soc. of Naval Architects of Japan. Recent field of work is control of the ship and computer sciences.

J. Vicedomine BSChE
Joseph Vicedomine obtained a BS degree in Chemical Engineering, with a minor in Control Engineering, from the University of Lowell in June 1985. Presently he is employed at Naval Sea Systems Command in the Control Engineering Division as Life Cycle Manager for Control Systems on all Gas Turbine Ships (DD963, DDG993 and CG47 Class) as well as the Mine Countermeasure Ships (MCM and MHC Class).

Dr. M. Vultaggio DrNautSc
Dr. Mario Vultaggio is an Associate Professor of Navigation at the Istituto Universitario Navale, Naples, Italy. He holds a Doctorate in Nautical Science from the Istituto Universitario Navale, Naples, Italy and a Master Mariner degree from the Italian Merchant Marine. He has seagoing experience as a 3rd and 2nd Mate on board Italian merchant ships. His fields of research were in Oceanography Surveying between 1972 and 1978. Starting from 1979 his research interests are Navigation, Cartography, VTS (Vessel Traffic Service) and Nautical Astronomy. He is the Italian Member of the European Project on Safety of Navigation COST 301. He is a member of the Italian Institute of Navigation.



J.M. Ward BTech BEng
Mary Ward joined Hawker Siddeley in 1984 after graduation from Loughborough University with an Honours degree in Mechanical Engineering. Throughout her degree course she was sponsored by Slingsby Engineering Ltd and was employed on mechanical design studies for bespoke underwater vehicles. Since joining Hawker Siddeley she has undertaken software design and system integration work on real time control, simulation and condition monitoring of gas turbines.

Commander W.N. Watson RN
Cdr. Watson joined the Royal Navy in 1958. He graduated from the Royal Naval Engineering College Manadon as a Marine Engineer in July 1965. He has held a number of sea jobs, including Marine Engineer Officer HM Ships TORQUAY, ARROW and HMNZS TARANAKI and two appointments as Squadron Marine Engineer Officer, latterly of the Type 22 BROADSWORD Class. His shore jobs have included "LEANDER" Desk Officer on the Staff of Commander in Chief Fleet, Deputy Captain Fleet Maintenance, Rosyth and Head of Marine Engineering, Director of Engineering Support (Naval). He recently spent a years sabbatical at Manchester University reading to an MSc in Condition Based Maintenance and Expert Systems. He is currently working for the Director General Marine Engineering, Ministry of Defence, as Head of Condition Based Maintenance and Condition Monitoring, responsible for the co-ordination and introduction of Condition Based Maintenance and Condition Monitoring techniques and procedures in all areas of Marine, Submarine and Weapon engineering and design throughout the Sea Systems Controllerate. Cdr. Watson is married with two children and lives in Callington, Cornwall in the South West of England.

Dr. A.C. Weaver PhD
Alf Weaver received the PhD in Computer Science from the University of Illinois in 1976. He joined the computer science faculty of the University of Virginia where he is now Associate Professor of Computer Science and Director of the Computer Networks Laboratory. His research area is protocol design and analysis for computer networks; his specialty is designing high throughput, low latency networks and protocols for use in real-time control systems. He is an ACM National Lecturer and a Vice-President of the IEEE Industrial Electronics Society. He is a consultant to NASA on the design of the communications system for Space Station Freedom.

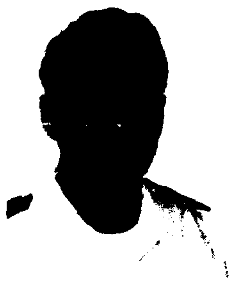
Dr. P. H. Wewerinke ir MSE PhD
Paulus H. Wewerinke was born in Groningen, The Netherlands, in 1945. He received the ir. degree (MSC equivalent) from the Delft University in 1969 and the MSC degree from the Princeton University in 1970 both in aeronautical engineering. He joined the National Aerospace Laboratory NLR in 1970 performing various studies of manual control and supervisory control systems. This includes aircraft display research, moving base simulation problems, pilot workload studies and mathematical modeling of human operator behavior. In 1985 he joined the System and Control Theory Group of the Department of Applied Mathematics at the University of Twente. Since 1985 he has also been with the Maritime Research Institute Netherlands MARIN, as an advisor concerning modeling research of ship handling. His major interests are in further development of models of human behavior in complex control and decision tasks and in large scale man-machine systems.

S.M. Williams MS
Received an undergraduate degree in Naval Architecture from the University of Michigan. He then started in the early stage ship design group at the Naval Ship Engineering Center (NAVSEC). After spending several years designing surface combatants, he studied at University of Newcastle-Upon-Tyne and was awarded a Masters in Ship Technology. He became the design manager for the T-ARC 7, then the MCM-1 and LHD-1 programs. He then moved to OPNAV and became the first deputy director of the Ship Characteristics and Improvement Board staff. His last NAVSEA position was Deputy Program Manager for Auxiliary ships. Since 1987, he has been Vice President in charge of Program Management for PDI CORP. During this period, he was responsible for the development of the DDG 51 simulator.

Dr. D.K. Wong BSc (Hons) PhD
Dr. Wong graduated with 1st class honours in Electronic Engineering from The City University, London in 1977. This was followed by a PhD awarded for advanced control work for an electromechanically suspended vehicle at Bath University. Industrial experience was obtained as a Teaching Company Associate at Heriot-Watt University with Lamberton Robotics. In 1986 he joined the Industrial Control Unit as a Research Fellow working on Marine control design and simulation project. The most recent of these projects was the fin stabilization control design development.

E.L. Woo BS
Mr. Everett L. Woo graduated from the University of Michigan in 1974 with a Bachelor's Degree in Marine Engineering. He has worked at the David Taylor Research Center in the Propulsor Technology Branch and the Surface Dynamics Branch. Currently he is working as a Senior Project Engineer in the Full Scale Trials Branch. Mr. Woo is the author of numerous reports detailing the maneuvering and powering characteristics of most of the new ship classes introduced by the Navy since 1976. A member of the Society of Naval Architects and Marine Engineers since 1973, he has co-authored a SNAME paper on the Ship-Model Correlation of Powering Performance on the FFG 7 Class.

J.K.C. Woo BSEE MBA
Mr. John K. C. Woo has been with Naval Sea System Command (NAVSEA) since 1968. He is responsible for the development and acceptance of the MHC/MCM (Mine Hunting Coastal/Mine Counter Measure) class ship machinery control systems, mine neutralization systems, sonar stems, and other combat systems. Mr. Woo has over twenty five years diversed engineering and program management experience both in U.S. government and in industry. His previous responsibilities include ASW research and development and Acquisitions/Production manager for AN/SQR-19 Tactical Towed Array Sonar System. Prior to 1968 Mr. Woo was systems design engineer for Grumman Aerospace Engineering Corporation responsible for system simulation, test and evaluation of Navy aircraft's radar, navigational and command control systems. Mr. Woo holds a Bachelor of Electrical Engineering from Indiana Institute of Technology and a Master of Business Administration from Adelphi University. He is a NAVSEA Certified Civilian Materiel Professional and a Defense Systems Management College graduate.



Commander F.C. Wyse BS MS PhD **USN**
CDR Wyse works for the Naval Sea System Command, Washington, DC, as the DDG 51 Class Machinery Control Systems project engineer. He has a B.S. from The Citadel, Charleston, SC an M.S. in management from the University of Southern California, and a Ph.D. in physics from Duke University. As an engineering duty officer in the U.S. Navy since 1972, he has had a variety of assignments involving the development and testing of digital combat systems, including equipment on the FFG 7, DDG 2/15, and DDG 993 Classes. From 1983 to 1986, he was an Exchange Officer assigned to the Royal Australian Navy. He has also participated in the research, development, test and evaluation of several advanced technology projects.

Dr. H. Yamato DEng
Associate Professor, University of Tokyo, Dept. of Naval Architecture and Ocean Engineering. BS(1977), MS(1979) and Dr. of Engineering(1982) all from University of Tokyo in the field of naval architecture. From 1982 till 1988, a project engineer for the Short Take-Off and Landing aircraft at the National Aerospace Laboratory of Japan. Member of AIAA, SAE, Japan Soc. for Aeronautics and Space Sciences and Soc. of Naval Architects of Japan. Recent field of work is control of ships and aircraft, CAD for the ship building and related areas.

Dr. W. Zhou BSc MSc PhD
Wei-Wu Zhou received his B.Sc in Mechanical Engineering from Xi'an Jiaotong University in 1970, his M.Sc. in Automatic Control from Dalian Marine University in 1982, and his Ph.D. in Automatic Control from the Technical University of Denmark in 1987. He worked as a Mechanical Engineer in three factories in China from 1971 to 1979. From 1982 to 1984, he was a lecturer of control engineering at Dalian Marine University and Jimei Navigation Institute. From 1987 to 1988, he was an Assistant Professor at the Norwegian Institute of Technology. He worked as a post doctoral fellow at the University of British Columbia, Canada from 1988 to 1989. Since November 1989, Dr. Zhou has been a Research Control Engineer at the Pulp and Paper Research Institute of Canada. His main research interests are identification, adaptive control and expert systems.

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Two indexes have been constructed to facilitate the search for information within these Proceedings:

1. **Index of Papers by Authors' Names:** This Index relates contributors' names to the Technical Papers for which they are the author or co-author. Opposite each name are listed the first page and volume of the Proceedings where each author's Paper(s) may be found.

2. **Index by Subject and Paper Title:** This Index lists every Technical Paper at the Ninth Symposium in alphabetical order. In addition, subject headings have been extracted from the paper titles. These appear in alphabetical order in the same list and are shown in bold capital letters. The Papers related to each subject heading are listed adjacent to the heading. Opposite each Paper Title is the first page and volume of the Proceedings where the paper may be found.

Please note that the page references state both the volume and the page number within the volume, eg 3.27 means page 27 in volume 3. There are 5 volumes, one for each of the five days of the Symposium. In addition volume 5 contains two papers which were accepted for publication, but not for presentation at the symposium due to time constraints.

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